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## THE FRANKLIN INSTITUTE.

*Stated Meeting, held Wednesday, October 19, 1904.*

## The Organization and Methods of a Modern Industrial Works.


BY J. WILMER HENSZEY.


The Baldwin Locomotive Works, in Philadelphia, is probably as good an example of a modern industrial works as we have in the country, and as I have been connected with this company for some years I will endeavor to give you an idea of how that plant is operated.

Baldwin Locomotive Works, at the present time, employ about 15,500 men, who are divided among twenty departments. The executive force consists of one superintendent, four assistant superintendents and twenty foremen. Owing to the extent of the works it is divided into two divisions, the eastern embracing all shops east of Fifteenth Street, and the western division taking in all shops west of Fifteenth Street, also new shops located at Twenty-sixth, Twenty-seventh and Twenty-eighth Streets. Each division

is in charge of an assistant superintendent, who works in conjunction with the foreman in his division.

In the eastern division the most important shop is the Erecting or Finishing Shop, located at Broad and Spring Garden Streets. This shop employs about 2,500 men, and has a capacity of fifty finished locomotives every week. To operate this department we have one foreman, two assistant foremen and twenty track foremen. Every track foreman is a specialist on a certain line, such as erecting, valve-setting, testing, etc., and has direct charge of the gang bosses and men who work under his supervision. The gang bosses, or contractors as we call them, are all picked men, the very best we can find, and have direct charge of the workmen. This same system of contracts is employed in every department throughout the works.

I will now explain our contract or piece-work system. Every department is a factory, manufacturing a certain number of locomotive parts. Through careful study we are able to ascertain the exact time and expense involved in making these parts; we then allow a certain amount of profit for the contractor in making price; he, in turn, gives out his work—piece-work—to his men at a slightly lower rate and makes the difference. There is a great diversity of opinion among manufacturers about the best way to pay labor. Some claim that you do not get the best results from the piece-work system because a piece-worker knows that he will not be allowed to make over a certain amount, and if he finds that he is making too much he will curtail his output sooner than run the chance of having his prices cut. This is true in some cases, but, under careful management, on routine work cannot occur. We expect and get more work per man out of our piece-workers than any similar concern in the world, and our men are allowed to make higher wages, and this, to my mind, explains why we never have strikes at Baldwin's.

In hiring a man we never ask whether he belongs to a union or not. We don't care. If he enters our employ he abides by our rules and regulations, which are posted in every department, and any attempt to incite trouble or dis-

satisfaction among the men is reported at once by his contractor and the man is dismissed.

A question that is often asked is, "Do you not have great trouble in procuring workmen who are skilled in the special lines of locomotive works?" We do. This is the question to which the Baldwin firm has given a great deal of attention in the past four years, and has led to the revival in our works of the old apprenticeship system, a brief outline of which may be interesting.

The apprentices are divided into three classes, first, second and third. To be a first-class apprentice a boy must be 17 years old and must have at least a grammar-school education. He serves four years. During this time he is allowed to stay on one class of work only three months, and is moved from department to department until he covers the entire plant. During the school season he is obliged to attend night-school two nights a week, taking up a special course in higher mathematics and mechanical drawing. He is paid from $3.00 to $6.60 per week during apprenticeship, and on completion of time receives a certificate and $250. A second-class apprentice must be a high-school graduate and serve three years on same lines as first-class apprentice. He also attends night-school. He gets from $4.20 to $6.60 per week, and on completion of time receives a certificate and $200. A third-class apprentice must be a graduate of a recognized technical school. He serves two years and does not take a night course. He gets from $9.00 to $12.00 per week and receives a certificate on completion of time.

We now have between 400 and 500 apprentices of the several classes, and it is proving of vast benefit to the works in providing a more intelligent and better class of labor than it is possible to get in any other way.

We claim that whether the apprentice stays with us or not on the completion of his time, he will always be a friend to the Baldwin Locomotive Works and look out for our interests, just as a college man does for his college. His training has made him a valuable man for railroad work, and one who will get ahead. It is a far-sighted business proposition.

A manager of a large shop has many other important matters to look after. If he is a progressive man, backed by a progressive firm, he wants to know the quickest and best way to get out work. Our firm encourages this among the foremen, and sends them all over the country to see how other people do work. If a foreman can prove that by the use of certain tools and appliances he can save time and expense, they are furnished him without question. During the past five years enormous strides have been made in this direction. By the aid of improved hydraulic and pneumatic tools hand-work has been reduced to a minimum, and on this alone nearly $1,000,000 a year is being saved on the cost of work in the shops. We have also made great savings on time required to do work by the use of specially treated tool steel for machine tools. By means of these tools we have been able to increase the capacity of some of our machines from 30 per cent. to 50 per cent. Our best results have been obtained from the Burgess Special Steel and the Sanderson Special Steel. All our new tools are being made from these steels, as ordinary tool steel will not stand the high speeds at which our tools are now being run.

It is interesting to see the vast difference between an up-to-date railroad or locomotive shop in this country and a similar shop on the other side. It has been my opportunity to visit a number of these shops in England, Sweden, Finland and Russia, and it is surprising to note the condition of their equipment. Power cranes are very rare even in the larger shops and the machinery is of a type in use here twenty-five or thirty years ago. It is not strange, noting these conditions, that we can build locomotives in Philadelphia, ship them to any country in Europe, and put them in service on their railroads, 10 to 20 per cent. cheaper than they can build in their own shops.

As orders for locomotives are received, they are printed on lists and put out in the shops. Each list contains two weeks' work; they are dated with delivery dates for each class of work in the various departments.

"The designation of the different classes of locomotives as used by Baldwin Locomotive Works embodies the com-

bination of certain figures with one of the letters *A*, *B*, *C*, *D*, *E* and *F*, to indicate both the number and kind of wheels and the size of cylinders. Thus, a locomotive having one pair of drivers is classed *B;* that with two pairs, *C;* that with three pairs, *D;* that with four pairs, *E*, and that with five pairs, *F*. The letter *A* is used for a special class of high-speed locomotive with a single pair of drivers. A figure 4, 6, 8, 10, 12 and 14 is used as an initial figure to indicate the total number of wheels under a locomotive. A figure or figures following the initial figure indicates diameter of cylinders, and the figure or figures following a class designation represents the consecutive class number of a locomotive on which it appears. Thus, 8 26 *C* 500 indicates a locomotive with eight wheels in all, having cylinders 16 inches in diameter with two pairs of driving wheels, and the 500 locomotive of its class." As soon as lists are put out, the Drawing-Rooms get them and start at once to design the locomotive, furnishing bills of material to the Purchasing Department, which orders all material we do not make. Lists are also furnished to every foreman and contractor in the entire plant. The great advantage of these lists is that every man in the entire works is after the material he needs long before it is wanted in the Erecting Shop, and we are rarely subjected to delay on delivery dates. Every foreman has a book of lists—check-books we call them—in which he keeps an exact daily check of every piece of work made in his department. He, in turn, checks off the superintendents', who can tell by their books at a glance the exact condition of every locomotive part in the entire works.

An important factor in the management of a large plant is the system of accounts.

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"(1) Manufacturing Account.

"(2) Commercial or Financial Accounts.

"In the manufacturing books a ledger account is kept with each locomotive constructed and with each repair-work job. All materials and labor are charged to these accounts either directly or eventually on closing the books. The

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principle is that no material or labor is paid for without being charged to an appropriate account.

"In the commercial books accounts of dealings with individuals and corporations are kept in the ordinary way. Both sets of books are closed annually and correspond exactly in their statements of expenditures and receipts.

"System of manufacturing accounts:

"In the general system of accounts by which the cost of construction of locomotives is ascertained each locomotive is charged as follows:

"A—*Materials.*—All materials used in the construction of the locomotives at the actual cost as fixed in the general contracts covering such purchases, or as paid for same at market rates.

"B—*Distributed Labor.*—All labor charged directly to the locomotives at actual cost of same, either by piece-work or day-work rate.

"C—*Expenses.*—All labor and materials incident to the construction of the locomotives, but which from their character cannot be charged direct. The cost of these is distributed to the locomotives in the proportion fixed by the amount of distributed labor as per paragraph B. Until this proportion is finally determined for each year it is based upon the accounts for the preceding year. The expenses include wages of managers, foremen, clerks, draughtsmen, stationary engineers, teamsters, laborers, watchmen, traveling engineers and messengers. They also include heating, lighting, repairs, insurance, taxes and other expenses on buildings, and tools, patterns and dies, defective work, printing, advertising, traveling expenses and all incidental costs connected with manufacture.

"D—*Disbursements for Freight and Delivering Locomotives.*—These consist of railroad charges for transportation to point of delivery."

The aggregate of the foregoing items is the cost of manufacture and delivery of locomotives.

One of the most important departments and one whose influence is felt over the entire works is the Test Department. This is equipped with two Tinius Olsen testing

machines for physical tests, and a complete chemical laboratory for chemical analyses, also with apparatus for indicating locomotives and stationary engines. Nearly all the material we use must first pass through this department, and be reported on before being accepted; this applies to all boiler steel, spring steel, tank steel, bar iron, cylinder iron, steel castings, oils, paints, etc. We have fixed standards for all these materials, which must be complied with before materials are accepted. The Test Department also has a corps of inspectors, who are stationed in the various rolling-mills and steel-plants we deal with, and whose duty it is to see that our mill specifications are lived up to, and that our orders are rushed through.

One of the important duties of a shop manager is the care of machinery. These machines represent thousands of dollars, and it is of the utmost importance that they be kept in perfect repair. To accomplish this we have in every shop a machine inspector or tool boss. This man is an expert on repair work, and has a gang of machinists under his supervision. As soon as a machine breaks, the fact is reported to the tool boss, who repairs it at once. A number of duplicate pieces of the most breakable parts of machines are always kept in stock, so that the machines are seldom down but for a very short time.

In every large plant, especially one having large smith shops and foundries, there is a constant danger of fire; to overcome this we have, I think, one of the largest volunteer fire departments in the country, having about 200 picked men scattered all over the works. We have twelve large Barr pumps and as complete apparatus as the city department. Every shop also is equipped with a sprinkler system, and has stand-pipes and reels of hose on every floor. Every few weeks we have fire drills, and it is remarkable how quickly our men can get into service. They put out on an average of two or three fires a month, and for several years have not had to call on the City Fire Department.

Another important matter is shop cleanliness. The sweepings must be run through separators, then loaded on cars and sent to firms who buy all our turnings.

Our sheet-iron scrap is carted to large scrap-bins built over railroad tracks in one of our yards. These bins have hinged bottoms, and when they are full, cars are run under them and loaded. This material is also sold, and proceeds from scrap and turnings amount to several hundred dollars a week.

The power of the works is handled by the Highway Department, which is also responsible for buildings, electric power and light and machinery repairs. We have four large power-houses, one at Broad Street, one at Sixteenth Street, one at Seventeenth Street, and one at Twenty-seventh Street, having thirty-one boilers generating 10,684 horse-power. Each power-house is in charge of a chief engineer, who makes a daily report to Highway office on a special form, giving an hourly account of steam and air pressures, and of the boilers, engines and compressors that were in service. By this means the foreman of the Highway Department is kept in contact with the power service throughout the entire works, and knows exactly how the pressures are being maintained at every hour of the day. We have 108 engines, pumps and air compressors, with 8,656 horse-power. All air compressors, dynamos for light and power and engines running them are located in power-houses, the other engines being located in the various shops.

As I have already stated, we employ 15,500 men, and to keep account of their time and wages is the work of our Time Department. Each man, on being hired, is given a number. The numbers for the men in each shop run in rotation. Each contractor has a piece-work book, in which he keeps a daily account of the time and wages made by each man in his gang. The time of all day workers is kept in a day-work time-book by the time-clerk. Once a week the Time Department takes the time records from the piece- and day-work books, entering the same on long printed sheets, giving the name and number of every man in each department. The piece-work books are gone over, and charges against each locomotive are entered to its cost account. The account of the wages due each man is then turned over to the Pay Department.

The Pay Department has pay envelopes stamped with the name and number of every man in the entire works. The amount of wages due is now stamped on each envelope. Our regular pay-day, with the exception of holidays, is on Friday, and every Friday morning the money is brought from bank. It has always been our custom to pay in coin, which is easier to handle, and clerks are less liable to make mistakes. The amount stamped on each envelope is then put in, the envelope is sealed and all are arranged in rotation, as to number, in an upright position, in specially constructed racks, each rack holding about 200 envelopes. These racks when filled are put in safes built for this purpose, and are now ready for the paymasters. We have two pay stations—one at Broad Street, in the Erecting Shop, and another at Seventeenth and Hamilton Streets. At the signal to quit work on Friday night, the men arrange themselves in long lines, according to number, at their respective pay stations, and at five minutes after 6 the line starts. We have eight paymasters, and run eight lines, the foreman of each shop, and his assistants, having charge of the lines his men are in. Each man as he passes the pay desk calls out his number to his foreman and his name to the paymaster, who passes him his envelope. It is possible in this way to pay our entire force in thirty minutes.

In conclusion, I will say that, to my mind, to get the best results from a shop you must have a unity of feeling among your men. Every man should be treated as a man, not as a machine. If a man comes to tell you about a supposed or a real wrong, he should be listened to, and given the proper advice. Your superintendents and foremen should not be shut up in offices to which the ordinary workman cannot have access, but should be as get-at-able as possible. This is, and has been, the policy of the Baldwin Locomotive Works, and to this policy their success, I believe, may, in large measure, be attributed.

## THE STRENGTH OF STEEL AT HIGH TEMPERATURES.

Prof. C. Bach has presented in the *Zeitschrift des Vereines Deutscher Ingenieure* the results of an elaborate series of tests of the strength of steel at high temperatures. Bars from three different works were tested, these being distinguished by the letters *O*, *K* and *M*. Of the bars *O*, four were subjected to tensile tests at ordinary temperatures, and successive lots of four to tests at the temperatures 200, 300, 400, 500 and 550° C. At ordinary temperatures the strength of the steel was for bar No. 2, for example, 27 tons per square inch, the ultimate extension on a gauge length of 8 inches 26·3 per cent. and contraction of area 46·9 per cent. The results of the tests showed that the strength increased up to 300° C. by about 3·17 tons per square inch, and from this temperature onward the strength fell, roughly in proportion to the temperature, to 13·1 tons per square inch at 550° C. The ultimate extension decreased from 25·5 per cent. at ordinary temperatures to 7·7 per cent. at 200° C., from which again it rose to 39·5 per cent. at 550° C. The contraction of area also fell at 200° C., but did not commence to rise until the temperature was above 300° C. In the case of the bars from the works distinguished by the letters *K* and *M*, tests were made by keeping the loads on for a considerable time. This prolonging of the action of the load had no effect until the temperature reached 300° C., at which point it caused a slight decrease of strength, and at 400 and 500 degrees a greater decrease. As regards the effect of prolonged loading on the extension and contraction between the temperatures of 300 and 400° C. it caused an increase in both, but from 400° C. the extension and contraction under prolonged loading decreased until at 500° C. they were lower by from 20 to 25 per cent. than with ordinary duration of test.

Professor Bach draws the conclusion from his investigations that for steam boilers, piping, etc., the strength of steel should be tested at the higher temperatures; and he is of opinion that this conclusion is justified not only by his experiments, but from the well-known fact of the brittleness of steel when worked at a blue heat.

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## DAMMING THE THAMES.

The damming of the River Thames at London is being considered by a royal commission. As there is a difference between high and low tide of 18 or 20 feet, all larger vessels must be handled in docks which can be closed by tidal gates. The object of the commission is to devise means for doing away with this inconvenience, and thus increasing the shipping facilities of the port. Among the plans presented is one for constructing a great dam across the Thames from Gravesend to Tilbury. This would convert the river into a great inland lake, extending from Gravesend to Richmond. At the point selected for the dam the river bed is of fine chalk, and the structure would give a navigable depth of 65 feet at Gravesend and 13 feet at London Bridge, without any dredging. The proposed dam would be made of concrete, granite-faced. The four locks would be 300, 500, 700 and 1,000 feet long and from 80 to 100 feet wide. The estimated cost is $18,290,000. As all the docks could be left open, there would be an annual saving of $250,000 in the cost of operating the gates.—*Iron Age.*

# Mining and Metallurgical Section.

*Stated Meeting, held Thursday, October 6, 1904.*

## The Molecule, the Atom and the New Theory of Matter.

By A. E. Outerbridge, Jr.,
Professor of Metallurgy, Franklin Institute.

[At the Franklin Institute, on Thursday evening, October 6th, Prof. A. E. Outerbridge, Jr., opened the proceedings of the sections by a highly interesting paper on the "New Theory of Matter," of which the following is an abstract.—Ed.]

The speaker said that twenty years ago he had given an address on "Radiant Matter" in the Auditorium at the Electrical Exhibition of the Franklin Institute, and since that time amazing discoveries have been made in cognate branches of science, causing new conceptions of the nature of the ultimate particles of matter out of which worlds are formed to dawn upon the minds of leaders of thought.

When philosophers like Lord Kelvin, Sir William Ramsey, Sir Oliver Lodge, Sir William Crookes and others, admit that the discovery of radium has upset all our preconceived ideas of the nature of matter, it behooves us to re-examine carefully the ground upon which we stand and try to comprehend the new views that have been advanced by such leaders.

The delicacy of the apparatus devised by modern physicists, and the refinement of experimental research rendered possible thereby, are among the greatest marvels of this wonderful age. The physicist is pushing his researches into paths which but a few years ago were thought to be forever hidden somewhere in the vast realm of the unknowable, and the boundary line between so-called physical and metaphysical science is continually narrowing; the philosopher has advanced, step by step, until he seems almost to have grasped the ultimate particles which constitute the physical

basis of the universe, and to have revealed to mortal eyes particles of matter too minute even for the mind's eye to comprehend.

It is a significant observation that all modern research tends to simplify Nature's laws, to show their intimate correlation and even to point still farther toward a complete unification or oneness of origin; thus the great forces of light, heat and electricity, though differing so widely in their effects on our senses, have all been resolved into "modes of motion," and it would seem a natural inference from the trend of modern scientific speculation that the now seemingly complex laws of nature's forces may all come at some future day—not far distant perhaps—to be comprehended in the study of the laws of motion.

Even matter itself, in its final analysis, is thought by some philosophers to owe its protean forms solely to difference in the movement of molecules or atoms; some years ago Lord Kelvin said: "That which we call matter may be only the rotating portions of something which fills the whole of space, *i. e.*, vortex motion of an everywhere-present fluid."

Professor Tait, following along the same path, said: "This property of rotation may be the basis of all that appeals to our senses as matter."

Professor Crookes said: "From this point of view, then, matter is but a mode of motion."

These views, which startled us when first announced, have been the advance couriers preparing us for the still more surprising statements recently put forth by leaders of scientific thought regarding the nature of matter.

The speaker said that before asking attention to the latest views regarding the nature of the ultimate particles of matter, it might be well to review very briefly some of the well-known laws and generally accepted theories regarding molecules and atoms.

The wonderful divisibility of matter has attracted attention from early times, and it was long thought that no absolute knowledge could ever be obtained regarding the nature of the infinitesimal particles out of which worlds

are formed. Indeed, one scientist, eminent in his day, said: "Of the ultimate nature of matter the human faculties cannot take cognizance, nor can data be furnished by observation or experiment on which to found an investigation of it." Lord Kelvin said, more recently, that they are "pieces of matter of measurable dimensions, with shape, motion and laws of action; intelligible subjects of scientific investigation." The same authority, undaunted by the complexity of the problems, deduced approximately, by four separate and distinct methods of calculation, the ultimate size of molecules, and in order to make the minute dimensions more readily comprehensible he has given this illustration: "Imagine a drop of rain, or a glass sphere the size of a pea, magnified to the size of the earth, the molecules in it being increased in the same proportion, the structure of the mass would then be coarser than that of a heap of fine shot, but probably not so coarse as that of a heap of cricket-balls." This represents the "coarse-grainedness" of matter.

Tyndall, in his charming "Fragments of Science," has given us some interesting ideas regarding the size of the particles constituting cometary matter. He says: "From their perviousness to stellar light and other considerations Sir John Herschel drew some startling conclusions regarding the density and weight of comets. These extraordinary and mysterious bodies sometimes throw out tails 100,000,000 miles in length and 50,000 miles in diameter. Now, suppose the whole of this stuff (*i. e.*, the matter forming the tail) to be swept together and suitably compressed, what do you suppose its volume would be? Sir John Herschel would probably tell you that the whole mass might be carted away, at a single effort, by one of your dray-horses. In fact, I do not know that he would require more than a small fraction of a horse-power to remove the cometary dust.

"After this you will hardly regard as monstrous a notion I have sometimes entertained, concerning the quantity of matter in our sky. Suppose a shell to surround the earth at a distance which would place it beyond the grosser matter that hangs in the lower regions of the air, say at the

height of the Matterhorn or Mont Blanc. Outside this shell we have the deep blue firmament. Let the atmospheric space beyond the shell be swept clean and the sky-matter properly gathered up. What would be its probable amount? I have sometimes thought that a lady's portmanteau would contain it all. I have thought that even a gentleman's portmanteau, possibly his snuff-box, might take it in. Whether the actual sky be capable of this amount of condensation or not, I entertain no doubt that a sky quite as vast as ours, and as good in appearance, can be formed from a quantity of matter which might be held in the hol low of the hand."

The divisibility of matter is at once a physical and a metaphysical question. It is obvious that masses of every form of matter known—saving perhaps the light-ether—are capable of division with more or less readiness. But is there any limit to this division other than the imperfection of the means employed? Here physics and metaphysics are at variance, and the former boldly avers that there is a limit. "A fragment of salt, for example, sustains subdivision only to a certain extent. Divide it but once again, and the salt as such disappears, and in its place we have the two new substances, sodium and chlorine. This limiting particle is called a molecule. It is the smallest particle of any substance which can exhibit the chemical properties of that substance. The aggregation of molecules constitutes a mass; hence the molecule is the physical unit—the ultimate particle or center of the physical forces. . . . An atom is the smallest portion of matter which can be reached by nature's processes of subdivision. It is generally defined as the smallest particle of simple matter which can enter into the composition of a molecule. . . . The word atom came into use to express a universally conceded fact expressed in the law of definite proportions, namely, that a certain definite quantity of matter by weight combines with a similar definite quantity of some other matter. The smallest quantity of any substance which is found ever to enter into combination is called an atom. No real objection can lie against the idea of atom when defined in this

way. If we concede that the molecule has as real an existence as a mass, I see no reason for not conceding the same to the atom." *

The speaker referred to Sir Wm. Crookes' discoveries in "Radiant Matter," and read the following excerpt from a report printed in the *Journal of the Franklin Institute*, April, 1881, of an address which he had given at the Institute on Professor Crookes' "Fourth State of Matter."

We are now prepared to ask, what is the character of the ultimate particle? This is a problem which has exercised the philosophic mind for many generations. The celebrated Italian poet and philosopher, Lucretius, speculated on this topic, and left a work called "De Rerum Natura"—*of the nature of things*—embodying his views, which are interesting even at this day.

Sir Isaac Newton invented, or adopted, the theory that all matter was composed of little, hard, incompressible spheres. This theory afforded him a plausible and ingenious explanation of certain discrepancies which he found to exist between the real velocity of sound in air, as proved by experiment, compared with the theoretical velocity, as calculated by him, based upon seemingly correct data. The theory, however, was found to be untenable, and was long since overthrown.

The idea of motion, as associated intimately with matter in some vague and unexplained way, seemed to be intuitively felt to be a necessity even before the time of Faraday, and a reaction from the hard atom theory of Newton brought out a class of philosophers who maintained that the so-called atom was not material at all, but that there existed in space certain foci, or centers of force; these points were supposed to possess the properties of attraction, repulsion, etc., and to behave in other respects as the most approved atom. This idea is believed to have been at least countenanced, if not actually adopted, by Faraday.

The wonderful investigations of Helmholtz on rotary

* "The Molecule and the Atom." G. F. Barker, *American Chemist*, November, 1876.

fluid motion paved the way for Sir Wm. Thomson's "Vortex Atom Theory."

This theory seems to explain many obscure phenomena, and, while we may hardly say that it is to-day the fully accepted creed of the scientific world, it is founded, not upon a rock, but upon the potent influence of the talismanic word motion, to whose eddying current the causes of so many of nature's grandest phenomena are now relegated.

"Sir Wm. Thomson's supposition is that the universe is filled with something which we have no right to call ordinary matter, but which we may call a perfect fluid; then, if any portions of it have vortex motion, they cannot part with it; it will remain with them forever, or at least until the creative act which produced it shall take it away again."*

This theory is far too complicated to admit of a clear exposition in a few words; but we will try to form an idea of it by means of a simple illustration. You know that a smoker may, by a peculiar adjustment of the mouth, accompanied by sudden muscular movements of the cheeks, skilfully exhale portions of the tobacco smoke in the form of beautiful opaque rings, which continue to rotate about their axes, gradually disappearing as the motion ceases; this is a vortex movement of the simplest order, and while it lasts the portions of the smoke forming the rings are separated and distinct from all the rest of the smoke in the room; and should this motion never cease (by the retarding influence of friction and gravitation), this smoke would remain differentiated forever and imbued with new properties in virtue of that vortex motion.

This crude illustration conveys the simplest idea of a most abstruse scientific speculation when referred to the hypothetical, all-pervading, perfect fluid, so essential to the existence of Sir Wm. Thomson's vortex atom.†

* "Recent Advances in Science," P. G. Tait.

† The subject of rotary fluid motion is such a forbidding one, from a purely mathematical point of view, that no one had done more than take a look at it, as it were, until Helmholtz gave us the fundamental propositions; splendid as they are, they are only a first step. Indeed, to investigate what takes place when one circular vortex atom impinges upon another, and the whole

The speaker alluded to the theory of "Compressible Atoms" advanced by Prof. Theodore W. Richards, of Harvard University, and to the interesting relation thereto, as noticed by him, of the remarkable permanent expansion of cast iron (exceeding 40 per cent. in cubic volume) when subjected to repeated heating and cooling.* In a recent letter Professor Richards said: "The theory of compressible atoms bears upon all the points which you bring up, and it seems to me that all are explicable according to it. Let us suppose that in a given pure metal the atom is equally attracted on all sides, and therefore equally compressed on all sides (this may or may not be true, but will serve as an initial assumption). If now the material is fused with another, forming an alloy, the atoms of each, being no longer symmetrically surrounded, will be unsymmetrically compressed and the volume change would be a very complicated function. This would also be true even if, in the first place, the pure metal's atom were not symmetrically compressed; in this case the change would still be bound to occur when the environment is changed. These considerations apply to most of your observations I think. In the case of 'Invar'† we must imagine that some shifting of affinities as the temperature rises must cause a contracting effect, which counterbalances the normal expansion of heated substance. The case may be supposed to be analogous to the probable state of water about 4° C., or to your interesting shift of affinities on heating cast iron, except that in this last case the shift involves an expansion instead of a contraction. As I understand it, in your case

motion is not symmetrical about an axis, is a task which may employ perhaps the lifetimes for the next two or three generations of the best mathematicians in Europe, unless in the meantime some mathematical method, immensely more powerful than anything we at present have, should be devised for the special purpose of solving this problem.—P. G. Tait, "Recent Advances," p. 298.

* See "The Mobility of Molecules of Cast Iron." A. E. Outerbridge, Jr., *Transactions* American Institute of Mining Engineers, 1904, and *Journal of the Franklin Institute*, February, 1904.

† Invar is a new alloy of iron and nickel which expands almost inappreciably when heated to a high temperature.

the shift of affinity is made manifest by actual change of structure. In the case of 'Invar' it cannot go so far as this, at least with moderate temperatures; on cooling, the structure must settle back to what it was before cooling."

The speaker said that since the discovery of radium and its remarkable properties it has been generally admitted that our preconceived ideas regarding the indivisibility of the atom, and, indeed, the whole nature of atoms and molecules, or, in other words, the nature of matter itself, need modification; at the present moment the scientific world is in suspense regarding the future; it is a moment of uncertainty, and while we may properly feel great desire to comprehend the new ideas in the minds of leaders of thought, we will certainly be justified in exercising caution in accepting new and revolutionary theories until further light shall have been cast upon the whole subject; meanwhile it is fortunate, in view of the present uncertainty regarding the nature of the ultimate particles of matter, that it is quite immaterial to our physical welfare whether the atom be divisible or indivisible; compressible or incompressible; whether it be a solid sphere, as Newton thought, or a mere focus of force, as other philosophers have maintained; this is an abstruse subject of academical importance only.

In his address on "Radiant Matter," already alluded to, the speaker said: "That mysterious agency or force, called electricity, has been utilized not only for hundreds of practical purposes, so fully illustrated in this grand electrical exhibition, but it has been employed by the physicist as a sort of finger to probe Nature's inmost structure, and it has enabled him not only, as it were, to see her mind, but, in some sense, to feel her pulse." Now we are actually told that electricity is the basis of all matter. This is the new theory.

Sir Oliver Lodge, F.R.S., in a recent paper entitled "Electric Theory of Matter," says: "What electricity itself is we do not know, but it may perhaps be a form or aspect of matter; so have taught for thirty years the disciples of Clerk-Maxwell. Now we can go one step further and say. matter is composed of electricity, and of nothing else—a thesis which I wish to explain and partially justify. * * *

"Our present view of an atom of matter is something like the following: Picture to one's self an individualized mass of positive electricity diffused uniformly over a space as big as an atom—say a sphere of which two hundred million could lie edge to edge in an inch, or such that a million million million million could be crowded tightly together in an apothecary's grain. Then imagine, disseminated throughout this small spherical region, a number of minute specks of negative electricity, all exactly alike, and all flying about vigorously, each of them repelling every other, but all attracted and kept in their orbits by the mass of positive electricity in which they are imbedded and flying about.* *

"Different atoms, that is, atoms of different kinds of matter, are all believed to be composed in the same way; but if the atoms of a substance are such that each possesses twenty-three times as many electrons as hydrogen has, we call it sodium. If each atom has 200 times as many as hydrogen, we call it lead or quicksilver. If it has still more than that, it begins to be conspicuously radioactive. * * *

"Matter then appears to be composed of positive and negative electricity, and nothing else. All its newly-discovered as well as its long-known properties can be thus explained—even the long-standing puzzle of 'cohesion' shows signs of giving way."

The most recent pronouncement may be found in an address on "The New Theory of Matter," delivered before the British Association for the Advancement of Science, by the Rt. Hon. A. J. Balfour, D.C.L., LL.D., F.R.S., M.P., president of the association.

Mr. Balfour says: "Surely we have here a very extraordinary revolution. Two centuries ago electricity seemed but a scientific toy. It is now thought by many to constitute the reality of which matter is but the sensible expression." Again he says: "To-day there are those who regard gross matter, the matter of everyday experience, as the mere appearance of which electricity is the physical basis; who think that the elementary atom of the chemist, itself far beyond the limits of direct perception, is but a connected system of monads or sub-atoms, which are not electrified

matter, but are electricity itself; that these systems differ in the number of monads which they contain, in their arrangement and in their motion relative to each other and to the ether; that on these differences alone depend the various qualities of what have hitherto been regarded as individual and elementary atoms; and that while in most cases these atomic systems may maintain their equilibrium for periods which, compared with such astronomical processes as the cooling of a sun, may seem almost eternal, they are not less obedient to the law of change than the everlasting heavens themselves."

Strange and incomprehensible as this electrical theory of matter may seem at first glance, it is, after all, but a modification of the vortex-atom theory, and it is incumbent upon us to realize that these new ideas, startling though they be, are not merely the imaginative inventions of scientific romancers, like Jules Verne, but are the serious thoughts of learned men who have delved deeply into original lines of research, and are recognized both as leaders of scientific thought and as eminent discoverers.

In conclusion, the speaker said that, although conscious of having imperfectly succeeded in his effort to elucidate so abstruse a subject as the modern conception of the nature of matter in the brief period of time available, he ventured, nevertheless, to hope that this little glimpse into the minute world of atoms and molecules might tempt his hearers to explore more deeply these interesting paths of knowledge, which have been so recently opened to view by toiling investigators who have taken the light of "pure science" for their guide, and have done much to enlarge the horizon of our mental vision and to expand our intellectual capacities.

# CHEMICAL SECTION.

*Stated Meeting, held Thursday, October 13, 1904.*

## Industrial Notes.

DR. BRUNO TERNE.

After an absence of nearly four years from Philadelphia, it affords me great pleasure to accept the invitation of my esteemed friend, Dr. Wahl, your Secretary, once more to address the Chemical Section of the Institute.

I can offer you no new discoveries, but I would like to call your attention, briefly, to some topics of technical chemistry which I have followed with special interest for years.

It is just about thirteen years ago (October 20, 1891) since I addressed this Section on the Utilization of the By-Products of the Coke Industry. We had quite an interesting and lively debate that evening.

Dr. H. W. Jayne said, in opening the discussion: "No one will deny the importance of the subject presented to us this evening, and I am aware that it has been carefully investigated by a number of large firms in the country, but as yet nothing has been done."

I took the broad view that no local interest, nor all the influence of all the gas-works combined, would be able to stop the development of the by-product coke-oven industry in this country.

My closing words in the records of this debate were: "The development of these industries is bound to come in spite of all opposition, nor will it be so far off. The right start is the most difficult point."

Now let us see where we stand to-day. It has been my personal good fortune to come in close contact through having business transactions with the present General Manager of the United Coke and Gas Works, Dr. F. Schniewind, the foremost leader of the modern coke-oven industry in this country, and by this means to follow the development of this industry step by step.

Dr. F. Schniewind represents the Otto system, whose patents are controlled by the United Coke and Gas Company of New York. The system has been greatly improved and made adaptable to the special wants of the different coal districts. We have one plant of this system in full blast on the other side of the river, in Camden, and a much larger one in operation at the steel-works at Sparrow's Point, Baltimore.

Interested parties will find no difficulty in getting permission to study these monuments of technical chemical engineering skill.

A close second to the expansion of the Otto system is the Semet-Solvay system, under the management of the Solvay Company, of Syracuse, N. Y. These two systems together have already made such progress that their output of by-products induced the parties controlling the output from the gas-houses to pool their interests and form a sales agency under the name of "American Coal Products Company," at 17 Battery Place, New York.

For fuller information on the statistics of this industry I refer you to the excellent essay of Dr. Schniewind, published in *Mineral Industry*, Vol. X, page 135, 1901–02.

The figures of the consumption and production of ammonia, as sulphate equivalent, for 1903 are as follows:

| Imports. | Sulphate Equivalent. |
|---|---|
| Sulphate | 16,770 net tons. |
| Muriate | 2,813 " |
| Carbonate | 2,636 " |
| Other forms | Insignificant. |
| | 22,219 net tons. |
| Domestic Production. | |
| Coke Works, Gas Works, Carbon Plants | Estimated 40,000 net tons. |
| Total domestic consumption | about 62,000 net tons. |

In the paper above referred to Dr. Schniewind estimates the production of sulphate of ammonia equivalent from the gas-works at 12,000 net tons. G. N. Parker, in *Mineral Resources* (1902), estimates the production at 15,641 tons.

Even if we allow the higher figures as correct and rounding up, allowing for the carbonizing plants with 17,000 tons, the sulphate of ammonia equivalent produced from the coke-ovens is 57½ per cent. of the total domestic output.

The increase of consumption has been, as compared with 1901, 14,178 tons, which mainly has been caused by the increase of the output of the coke-ovens.

To-day the Semet-Solvay Company has 650 ovens in operation in eight localities, and 120 ovens in course of erection.

The Otto system, represented by the United Coke and Gas Company, has 2,753 ovens in operation, with an output of 16,825 tons sulphate equivalent.

Taking these figures as a basis, they would leave for:

| | | |
|---|---|---|
| Gas-works | 15,000 tons. | |
| Otto system | 16,825 " | |
| Semet-Solvay | 8,175 " | sulphate equivalent. |
| | 40,000 " | |

These figures may not be absolutely correct, but they are near enough to give you a true estimate of the relative proportion of the sources of ammonia production.

Thirteen years ago there was not a pound produced by the coke-ovens; to-day they yield from 25,000 to 30,000 tons per annum. This is only the beginning of the by-product coke-oven industries. At the present moment there is a stagnation in the steel industries, and consequently during the last two years very little has been done toward development of new systems. Those under contract have been finished or are nearly finished. This dullness will shortly disappear, and with the revival of the steel industry, the extension of the by-product coke-oven will go on step by step. The system has been firmly established, the prejudice against it proven by practical experience to be without basis, and the beehive oven will gradually be replaced.

I cannot help looking back to our meeting thirteen years ago with some satisfaction, knowing that I have been supported in my prediction by the actual facts of progress of which I have laid figures before you.

The production of coke may play an important part for domestic fuel, as well as for factories to help to minimize the smoke nuisance. The time is rapidly approaching when the home production of sulphate of ammonia, or its equivalent, will exclude importation, and further on will reverse the statistics of trade. The fear has been expressed that over-production would ruin the prices of the by-products to such an extent as to make the process unprofitable. There need be no fear on that score. Not only is the domestic market daily extending, but the foreign market also will, in the near future, come in with large demands.

The most powerful competitor of sulphate of ammonia in the broad field of the fertilizer trade is the nitrate of soda of Chili.

The source of this raw material is rapidly nearing complete exhaustion, and as nitrate of soda is consumed not only as a fertilizer, but also for other uses in the arts, it is to be expected that it will presently cease to play an important role as fertilizer material. Something else will have to take its place. The most available substitute is sulphate of ammonia.

You all know that a complete fertilizer must contain:

> Nitrogen, or its equivalent in ammonia;
> phosphoric acid in available form, and
> potash.

But all the different brands are wholly or partially mechanical mixtures, and the idea occurred to me, why should I use sulphate of ammonia in dry mechanical mixture, when I could make a better and cheaper compound of ammonia phosphate by using directly the ammoniacal liquors with the acid phosphate while in process of making it?

I made experiments on the manufacturing scale, and succeeded in producing a high-grade ammoniated phosphate at figures which will allow its profitable production. I secured by letters-patent, No. 709,185, the principle of the direct use of the ammoniacal liquors for this purpose. Without going into details, I will say that I have the endorsement of the leading agricultural chemists, as well

as the endorsement of the leading dealers for this product, of which I show you a sample.

Pending some negotiations, I expect presently to develop this process on a large scale, thus opening a new and direct use of the ammoniacal liquors of the by-product coke-oven in large quantities.

While I was engaged as chemical manager with several large companies for the utilization of garbage, and trying to improve the utilization of this material on a rational basis, I made experiments to produce the ammonia from it by destructive distillation.

In 1897 I communicated with Mr. R. M. Atwater, then secretary of the Semet-Solvay Company, Syracuse, N. Y. My suggestion was well received, and induced the Semet-Solvay people to make some preliminary tests in an experimental retort with material furnished by me. On the basis of these results, which confirmed my own, the Semet-Solvay people desired to make a large run in their regular coke-oven, for which purpose I furnished, from the Barren Island Works, a carload of pressed garbage.

At the time of working our material I was in Syracuse and witnessed the work, which was in charge of Mr. W. F. Blauvelt, now Chief Engineer of the Solvay Company, Syracuse.

The following is the summary of the report made:

The garbage was tested under various times of coking, and with varying percentages of moisture, with the result that there is no doubt that the full charge of 4 tons of dry garbage can be coked in twelve hours, or two charges per day. The average percentage of moisture in the garbage was 27·2. The total amount of garbage tested was 26,940 pounds, equivalent to 20,420 pounds of dry garbage. The maximum charge in any oven was 7,645 pounds. Total dry residue, 6,580 pounds, 32·3 per cent. of the moist garbage charged. The residue was composed of fine granular carbon mixed with bits of coking, wire, tin cans and other refuse material. Upon screening over ¼-inch screen, 26·5 per cent. coarse material remained. Of this screened material, 25 per cent. was carbon.

The yield of by-products is as follows:

Yield of ammonium sulphate per 2,000 pounds moist garbage, 61·3 pounds.
Yield of gas, 6,840 cubic feet.

ANALYSIS OF GAS.

| | No. 1. | No. 2. | |
|---|---|---|---|
| $CO_2$ | 16·9 | 16·1 | Carbon dioxide. |
| $C_2H_4$ | 0·0 | 0·7 | Illuminating gas. |
| CO | 37·0 | 28·7 | Carbon monoxide. |
| O | ·2 | ·6 | Oxygen. |
| $CH_4$ | 7·6 | 10·5 | Marsh gas. |
| H | 32·8 | 36· | Hydrogen. |
| N | 8·5 | 7·7 | Nitrogen. |
| | 100·0 | 100·3 | |

**Total combustible, No. 1 = 74·7 per cent.; No. 2 = 75·2 per cent.**
**The results in the experimental retort were higher.**
**Sulphate of ammonia obtained by this test was 65·25 pounds for 2,000 pounds moist garbage.**
**The dry residuum was 43 per cent.**

The large difference between the residue obtained in the retort and in the ovens is doubtless due to the amount left in the ovens after pushing, and the loss from blowing away and washing away with water while quenching.

It was now a matter of calculation to see if the higher yield of sulphate of ammonia could balance the lower yield of gas and the absence of coke as a marketable commodity.

The gas produced reaches within 1,000 cubic feet per ton of material. The gas production from an average bituminous coal will be sufficient to serve as fuel to keep the oven going without any extra fuel supply.

If the ovens are in proper order there will be sufficient surplus of gas to produce the steam required for the ammonia plant. The solid residuum contains sufficient phosphoric acid and potash to make it valuable as a fertilizing material, which, by mixing it with the concentrated tank-liquors, will be greatly improved.*

After going carefully over all these points and calculating closely in comparison with the older method, the New England Sanitary Product Company, of Boston, and the Semet-Solvay Company made an agreement the 22d day of April, 1898, to erect jointly a plant to take care of the garbage of the city of Boston with the production of ammonia by the

* See United States Patent No. 619,056, February 7, 1899.

adoption of the Semet-Solvay coke-ovens modeled for this purpose. The plant, which should have been ready in July, was not finished until late in the fall. It consisted of a complete system of seven ovens with all auxiliary apparatus for the production of ammonia liquors and sulphate of ammonia, with a capacity of 45,000 pounds for the ammonia department.

The general plant was designed by the engineer of the Sanitary Company, Mr. Charles Edgerton, of Philadelphia. The coke-ovens and apparatus pertaining to them were designed and built by the Semet-Solvay Company. A detailed description of this plant, with drawings, is given in the *Engineering Record*, September 14, 1901, page 251, by Mr. C. G. Atwater, who represented the Semet-Solvay Company at the Boston plant.

You will have noticed that the moisture in the material for the Syracuse test is a little lower than 25 per cent. This is lower by 10 per cent. than the average of the fresh material from the presses at that time in use at Barren Island. The press work was the most objectionable part of the utilization plants from a sanitary point of view, and it was the steady aim of the engineering force to overcome the nasty work of charging the old knuckle-joint screw process.

We have made numerous experiments with many different kinds of presses, with centrifugals of different styles, but not with success. Finally, Mr. Charles Edgerton designed a roller press which, from a sanitary point of view, overcomes all objections, and as a labor-saving device cannot be excelled; but it had one great fault—it did not give the same result either in moisture or in grease.

In eleven tests which I made from December 10 to 31, 1898, the result was:

| | |
|---|---|
| Moisture | 52·38 |
| Grease | 5·84 |

In January, 1st to 7th, stock taken from storage on top of the oven ran as high as 62·84 per cent. moisture. This excess of moisture was death to the work of the ovens. We simply could not keep up the heat in the ovens; the retorts were changed to boilers. It takes not much argu-

ment to convince any one that under such conditions the ovens could not give satisfactory results. It was a most deplorable condition of circumstances that the introduction of the new presses absolutely spoiled the well-calculated work of the ovens.

The condition in Boston was such that the award of the contract depended on the performance of the new press, and there was nothing left to be done but to try to improve the work of the press to reduce the moisture, but it seemed absolutely hopeless to reduce the moisture to much less than 50 per cent.

We went to the limit to close the presses down, but we could not afford to keep it up—first, because the rollers would not get sufficient material through; and second, the breakage of the driving gears was so bad that it would have necessitated a special machine-shop and foundry to keep us going. Under these circumstances we came to the conclusion to put up a revolving drier, heated with the waste heat from the boiler, to improve the condition of the pressed garbage. After much loss of time we succeeded in reducing the moisture to such a degree that the ovens commenced to show results, and we accumulated ammoniacal liquors, which gained in strength from day to day. Improvements in the gearing of the presses at the same time helped to get a better raw material, and supported the drier in its work. Everything pointed to the way of final success. We had filled our weak-liquor storage tanks, and commenced to concentrate for shipment. We had made several hundred tons of fertilizer ready for the market when fate threw us down and out.

On the morning of February 10, 1899, a disastrous fire destroyed the plant. The whole by-product plant, with the exception of the ovens, lay in ruins, and therewith ended the chapter of our attempt to utilize the coke-ovens for the utilization of garbage, at least for the time being. But by no means had our well-calculated plan, based on a different condition of the raw material, been proven to be incorrect. It was the one change in the condition of the raw material which caused all the annoyances and delays, and it was this point which frustrated the rebuilding of the plant.

Rather than go on again under the same conditions, the Solvay Company accepted their loss and canceled their contract. The plan to utilize the coke-oven product for the utilization of garbage is to-day as correct as when we made the tests in Syracuse, but the material must be of the same consistency as that which I sent to Syracuse.

The roller-press, even to-day, is not an efficient machine because it does not give sufficient pressure, and also leaves too much moisture and grease in the product. As I said before, the press works clean, it creates the least nuisance, it takes fewer men to work it, but the product cannot be compared with the product of the hydraulic presses at work with the same material at Barren Island and Philadelphia.

If the ammonia market is favorable, pressed garbage with 25 to 30 per cent. of moisture will form a good raw material for its production. I would, if I should build another plant, modify the system of horizontal retorts to vertical ones, as both charging and discharging can be more easily arranged and the loss of material in discharges greatly reduced; the material should come from the presses by all means with no more than 30 per cent. moisture, which can then easily be reduced 10 to 15 per cent. more before entering the retorts.

There is a disposition among the large companies controlling the utilization of garbage to be satisfied to produce only grease and allow the rest to go to waste. An exception is the Barren Island plant, where the fertilizer is made in both conditions, improved with the tank liquors or in the original state. The plants in Boston and Philadelphia either sell the pressed garbage or use some under the boilers for fuel. In either case it is a waste, and the plant is not worked as it should be.

It is a miscalculation to lose the fertilizer; all figures to the contrary are based on wrong premises. It is certainly easier to handle, but it is incorrect and not to the manufacturers' interest to throw away these products for which there is a large demand.

I may be allowed to make one more remark about the peculiar ideas in existence regarding the garbage business.

There is annually a great outcry in Philadelphia when the contracts for the following year have to be given out. We are going through this again, and the newspapers have an easy time filling their columns. As usual, some one is kind enough to help them out by making some nonsensical proposition.

The most nonsensical error made in this proposition is, to pay for each ton of garbage, delivered to an imaginary plant, $1 per ton to the city. I take from the *Ledger* clippings the following figures:

The writer places the total number of tons of garbage collectable at 380,000 tons per annum; this means 1,200 tons per day of 300 working days. There are not 500 tons a day to be found in Philadelphia; the whole case is built on talk of the wildest kind, and with it the whole calculation falls like a house of cards. It is only surprising how the Department of Public Works, which has access to the statistics of the works, can be led astray by such wild talk of imaginary profits and give color of approval to it by their vacillating action.

The utilization of the garbage of our great cities can be the basis of a well-paying business if the material is brought to the works free of cost; the gathering of the material is a department of this business which must not only be self-sustaining, but should show profit in itself. The products possible must all be made in the most economical way; but there should not be for manufacturing reasons a break in the chain. The more complete the yield of marketable products is made, the larger the profits. If, at the beginning of new enterprises—like the whole garbage industry—obstacles common to all new enterprises have to be overcome, they have already, for the largest part, been met successfully, and should by all means, by steadily improved methods, be overcome without difficulty.

The fertilizer produced from garbage, while only of a low grade, 3 to 4 per cent. ammoniacal tankage, has a wide field in the trade because of its physical qualities, as an excellent filler and for which there is a great want. The farmer who spreads his fertilizer over a large area likes to

have a large volume to work on. At the same time the demand is for a low-priced product. Consequently the manufacturer of fertilizer must look for material which fills the double requirement of "cheapness and volume." Nothing can fill the bill better than the garbage tankage.

It is to be hoped that the former policy of using everything will be restored where it has been suspended. The demand for cheap tankage has caused the utilization of other waste material such as cheap manure products, etc. In Illinois, in the center of the corn-belt, where the great distillers are situated, in Peoria and Pekin; in Terre Haute, Ind., and other places, the feeding of cattle forms an important factor for disposing of the waste from the distilleries. In the stables of Peoria and Pekin there are from 20,000 to 30,000 head of cattle. You can imagine what a quantity of manure material the animals produce. So far all this material goes to waste and simply helps to contaminate the Illinois River.

While St. Louis is trying to control the Chicago Drainage Canal, claiming that the contamination of the Mississippi River is caused by it, they would better look further down the river and examine the water above and below Pekin–Peoria before pressing their fight against the drainage canal.

I was lately interested in an attempt to utilize the stable offal for the manufacturers of sulphate of ammonia and manure tankage in Pekin, Ill.; this attempt, however, was unsuccessful.

It is a very nice problem in technical chemistry which can without doubt be solved financially, if the necessary capital for the right equipment *is forthcoming at the start.*

In the atmosphere surrounding our globe we have an inexhaustible source of nitrogen, but we have thus far failed to make these riches serviceable to the cultivation of our soil. It seems now that we are in a fair way to accomplish this object in a practical way by two entirely different modes of procedure.

Numerous attempts have been made without practical results, but at last the work of the electric furnace seems to be on the point of being successful.

I will read to you an abstract from a recent report of F. H. Mason, U. S. Consul-General at Berlin:

NEW ARTIFICIAL NITRATE.

The gradual but ultimately inevitable exhaustion of the known nitrate deposits of South America lends a growing interest to the methods which have been devised for obtaining a supply of nitrogen for fertilizing purposes from the inexhaustible storehouse of the air. That this can be done as a scientific process has long been known. The first method was by passing a current of air over red-heated copper, whereby the oxygen combined with the metal to form oxide of copper, leaving the nitrogen free. At first the nitrogen thus produced was fixed by combination with calcium carbide to form . . . (Kalkstickstoff) or calcium cyanimide, a combination of lime, carbon and nitrogen, which had all the essential properties of a nitrate fertilizer. But as the use of calcium carbide rendered the product unduly expensive, a method was sought which would employ a substitute for that material, and this was found by Dr. Erlwein, who brought the nitrogen into combination with a mixture of powdered charcoal and lime in an electric furnace. The product of this combination is a black substance containing, besides the lime and carbon, from 10 to 15 per cent. of nitrogen in perfect condition to be used as a fertilizer. From the experiments thus far made with this new article—which is known in commerce as calcium cyanimide—it appears that its nitrogen acts upon plants quite as effectively as that contained in a proportionate quantity of nitrate of potassium or sodium nitrate (Chili saltpeter). The scientific problem of obtaining nitrogen for fertilizing purposes from the atmosphere would seem, therefore, to be satisfactorily solved. Whether it can be done on a very large scale and at a cost which will make it economically available for general agricultural purposes remains to be demonstrated by practical experience.

I have not been able, in the short space of time allowed for the preparation of these notes, to find specific reports of the work of Dr. Erlwein so as to form an idea of the practical success of this process. The wonderful success of the electric furnace in other branches of applied chemistry permits us, however, to anticipate the solution of this problem also, and we may not unreasonably hope for the successful production of artificial nitrate in the near future on a practical basis.

Ever since the soil has been cultivated the farmer learned to know that after a crop of leguminous plants, such as beans, clover, peas, etc., the soil seemed to be benefited by it; not only that these plants required less fertilizer than others, but also that they directly helped to fertilize the soil for the succeeding crops.

Based on this experience, a rotation of culture has been established, and is used by every intelligent farmer. It is only recently that the reason for the beneficial action of these plants has been clearly established.

The investigations of Dr. Fr. Nobbe, a noted agricultural chemist, of Germany, were the first to call attention to the fact that the peculiar formation of nodules or tubercles on the roots of these plants was due to the action of innumerable bacteria, and that, unless these tubercle bacteria exist, the plant is no more able to fix the nitrogen of the air than any other plants which do not have such nodules on their roots. This fact established, it was the aim to cultivate such microbes to insure the formation of the tubercle.

Several years ago German investigators put upon the market a product known as nitragin, which purported to be a pure culture of the root-tubercle organism.

The results, however, were disappointing. In a few instances, in Germany, excellent results were obtained, but in the majority of cases the crop was not better than without inoculation. The preparations of nitragin were sold in bottles prepared for each different crop. The result here, with the nitragin imported, was still worse; fully 80 per cent. of the culture turned out to be a failure. The nitragin has now disappeared from the market. The failure to give permanence to the microbes in the fluid preparation was the reason of the uncertainty in its application to the soil. At this juncture the Laboratory of Plant Physiology of the Bureau of Plant Industry in Washington took up the research. It was soon found that the method in use by the German investigators was not adapted to maintain the life of the organism; that is to say, the use of nitrogenous food material, such as decoctions of the host-plant, was not calculated to produce an organism which would fix free nitrogen from the air.

It was found that, while the bacteria grew luxuriantly upon such media, they became less and less active, until eventually they lost completely the nitrogen-fixing power. It seemed as though the large amount of nitrate in the media upon which they were grown made it no longer

necessary to draw nitrogen from the air. It was found, however, that by gradually reducing the amount of nitrogen in the culture medium it is possible to greatly increase the nitrogen-fixing power of these germs, and that by proper manipulation this may be increased from five to ten times that which usually occurs in nature.

The attainment of these remarkable results is the work of Dr. George T. Moore, in charge of the Laboratory of Plant Physiology, U. S. Department of Agriculture. They place him in the front rank among plant physiologists and as a benefactor to mankind. With unexampled liberality he has given the results of his researches for free use by the farming communities of the United States.

He filed a patent application May 4, 1903, and letters-patent were granted to him March 22, 1904. The patent is of such importance and gives so clear a description of the process that I introduce it as part of this paper.

UNITED STATES PATENT OFFICE.

No. 755,519. Patented March 22, 1904.

George T. Moore, of Washington, District of Columbia.

Process of preparing for distribution organisms which fix atmospheric nitrogen.

Specification forming part of letters-patent No. 755,519, dated March 22, 1904.

Application filed May 4, 1903. Serial No. 155,695. (No specimens.)

*To all whom it may concern:*

Be it known, That I, George T. Moore, a citizen of the United States, residing at Washington, in the District of Columbia, have invented new and useful improvements in the process of preparing for distribution organisms which fix or gather atmospheric nitrogen, of which the following is a specification:

*This application is made under the Act of March 3, 1883, Chapter 143, and the invention herein described and claimed, if patented, may be used by the Government of the United States or any of its officers or employees in prosecution of work for the Government or by any other person in the United States without the payment to me of any royalty thereon.*

The invention relates to the process of growing these organisms and preparing them for distribution.

The invention has for its object the production of more highly effective organisms and their distribution in a form preventing deterioration, and easily applied in agriculture. All work that has heretofore been done in the cultivation of nitrogen-gathering root-tubercle organisms for use in agriculture has been done in culture media containing either decoctions of the leguminous

plants, from which these specific organisms in each case were obtained, or in media containing some other available form of combined nitrogen not free or atmospheric. When there is available combined nitrogen in the medium, the organisms, instead of depending solely upon the atmospheric nitrogen for their nitrogen supply, draw upon the nitrogenous materials of the culture medium, such, for example, as proteids, nitrates, ammonium compounds, etc., for which reason they do not develop their full nitrogen-gathering power and rapidly deteriorate.

By my process the organisms are first obtained from the tubercles or swellings on the roots of the leguminous plants, such as clovers, cow peas, beans, etc. After the tubercles are thoroughly washed and surface sterilized in the ordinary ways, the interior of the tubercle is cut out under sterile conditions and mixed in a medium consisting of water containing about 1 per cent. commercial agar-agar, about 1 per cent. maltose sugar or cane sugar (the former being the better), about ·02 to ·05 per cent. magnesium sulphate and about 0·1 per cent. monobasic potassium phosphate. This solution is made up in the ordinary way, and sterilized according to ordinary bacteriological processes. It differs from ordinary culture media for bacteria only in the absence of a source of combined nitrogen. The agar may be varied above or below the amount suggested. The maltose or cane sugar may be increased to 10 per cent., the magnesium sulphate to 1 per cent., the monobasic potassium phosphate to 2 per cent., or the amounts may be lowered below the quantities first mentioned. In the latter case, however, the food materials are more quickly used up. The organism multiplies as long as the materials in solution are not exhausted. Other compounds may be used as sources of magnesium, potassium and phosphoric acid. Although I usually leave nitrogen out of the culture medium at this stage, its absence is not essential, as the object of the first step is simply to separate the organisms into pure cultures, free from mold or other contamination, the process of separating out in this fashion being familiar to all bacteriologists and in common use. They grow best between 20° and 30° C., and light or its absence is immaterial. When pure cultures are thus obtained, the organism is transferred immediately, or after several weeks, if desired, by any of the bacteriological transfer methods in use, to water containing about 1 per cent. cane sugar or maltose (the latter being the better), about ·02 to ·05 per cent. magnesium sulphate and about 0·1 per cent. monobasic potassium phosphate, or equivalent sources of magnesium, potassium and phosphorus, as in the case of the first-described medium. The quantities used may here also vary, as stated above; but the per cents. given have been found to be the most favorable for growth under ordinary conditions. One cubic centimeter of the culture will suffice for impregnating 100 liters of the fluid. Any kind of container or vessel that can be easily cleaned will serve for this purpose; but Erlenmeyer flasks are best where small quantities are to be cultivated under antiseptic conditions. In this solution, which should be kept between 20° and 30° C., in light or in darkness, as desired, the organisms increase very rapidly, and have to obtain all of their nitrogen in the free state from the atmosphere or from the atmospheric nitrogen in solution in the medium. This liquid culture solution, even when in large quantity, will in a few days become milky in appearance by the presence of immense numbers of the developing organisms. The

water containing the organisms, where direct use is desired, is then sprinkled upon seeds or soil; but for the purposes of preservation and distribution the following steps are taken: Absorbent cotton or other equivalent material is dipped into the water containing the organisms, or the water containing the organisms is sprinkled upon the cotton or other material, and the same thoroughly air-dried in a chamber free from dust or contamination from molds The drying is facilitated by forcing a current of air through the chamber by aspiration through sulphuric acid, potassium hydroxide, sodium hydroxide or any of the other ordinary materials used in laboratories for drying. In this dry form the organisms may be kept indefinitely without deterioration or change, and may be safely, easily and cheaply transported to any distance, either through the mails or otherwise. In using the organisms preserved as above described the dry absorbent material containing them is simply dropped into a water solution of the same composition as above described. Where the purpose is to treat soil or seed, it is not necessary to observe strictly antiseptic precautions. Ordinary clean vessels or tubs may be used, simply protected from dust, and ordinary well-water or rain-water is used in making the culture solution, as the amount of nitrates or ammonia which such waters ordinarily contain does not interfere with the vitality of the organisms at this stage of the process. The temperature and light conditions should be as previously stated. In from twelve to forty-eight hours the organisms will have increased in the water culture, as in the first instance. At this stage, in order to stimulate a very rapid division of the bacteria, about 1 per cent. phosphate of ammonia is added to the culture solution. The quantity of liquid culture that may be thus obtained is limited only by the amount of water used containing the sugar, magnesium sulphate and potassium phosphate or other equivalent sources of magnesium, potassium and phosphorus, as above described. After thus obtaining the liquid culture, it is then necessary only to sprinkle the seeds or soil to be treated with water containing the organisms, or to dip the seeds into water containing the organisms, and then dry them in the ordinary way to facilitate planting. The propagation of the bacteria should not be continued longer than from twelve to forty-eight hours after the addition of the phosphate of ammonia; otherwise they will deteriorate in nitrogen-fixing power, as previously explained, and organisms thus stimulated should be used only for seed or soil impregnation, and not for preservation or distribution.

Having thus described my invention, what I claim, and desire to secure by letters-patent, is:

The process of preparing for distribution nitrogen-gathering organisms, which consists in moistening suitable absorbent material with a solution in which such organisms are suspended, and afterward thoroughly drying the said material substantially as hereinbefore described.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

(Signed) GEORGE T. MOORE.

Witnesses:

(Signed) A. F. WOODS,
GEO. P. MCCABE.

The Department of Agriculture, recognizing the importance of this investigation, has set out at once in the most practical way to make it possible for any progressive farmer to reap the fruits of this discovery, and make his barren land serviceable. For full information I refer to the "Year Book of Agriculture" for 1902, and in more popular form to the October *Century Magazine*. Through the kindness of Prof. H. W. Wiley I received a day ago a sample of the material as sent out by the Department, which I have now the pleasure to present to you.

The practical results achieved in the short time since the development of this industry of our Agricultural Department are of inestimable importance to the farming interests of our land. The cultivation of the nodule-producing bacteria and their preparation for distribution the world over without deterioration is a wonderful discovery. The first attempt to make the nitrogen of the air serviceable to the cultivation of the soil has been successfully made. Although limited to the cultivation of leguminous plants, it is of invaluable benefit to all crops by their judicious rotation.

As the experiments with the electric furnace to utilize the nitrogen of the atmosphere indicate coming success, and with the assurance of a steady increase in the production of ammoniates by the coke-oven process, and the utilization of all organized ammonia sources, we need not fear that the exhaustion of the South American nitrate beds will injuriously affect the fertilization of our land with nitrogen.

It has always been, and will always remain true, that as one material is exhausted it will be replaced by the utilization of others.

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## ELECTROLYTIC CONVERTER.

In certain branches of Röntgen-ray work, particularly in the medical department it is desirable to secure very rapid pulsations of the current, and also to provide an interrupted direct current instead of an alternating current. For this purpose, W. B. Churcher makes use of the ordinary Röntgen-ray bulb connected to the well-known induction coil, but as a source of interrupted current for the primary of the coil he employs a special type of electro-

lytic converter, for which a patent was granted to him August 9, 1904. The cell, of which the electrolyte is preferably sodium or potassium phosphate, contains three electrodes, two of aluminum and one of some metal not easily attacked by the electrolyte, such as platinum or gold. The aluminum electrodes are connected directly to the outer leads from an alternating-current transformer, while the two primary terminals of the induction coil are connected respectively to the neutral point of the transformer coil and the third (gold or platinum) electrode of the cell. Under operating conditions the third electrode will be positive to one of the aluminum electrodes and negative to the other at either phase of the current. The nature of aluminum in an electrolyte is such that only negative current will flow from the platinum or gold electrode to whichever of the aluminum electrodes happens to be positive thereto. The interruptions of the current, other than what are due to the alternators of the supply system, are produced by reason of the small surface of the platinum or gold electrode which is exposed to the electrolyte, and at which, upon passage of the current, there is produced gas in sufficient quantity to insulate the electrode and interrupt the current.—*Electric World.*

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## PROFESSOR PICKERING'S REPORTED LUNAR CHANGES.

Prof. William H. Pickering, now temporarily located at the Lowe Observatory, Echo Mountain, California, reports that on the night of July 31, 1904, a bright, hazy object 2 sec. in diameter was noticed upon the floor of the lunar crater Plato. Observations made July 21st, 22d, 23d, 26th, 27th and 28th had shown nothing unusual at this point. August 2d in place of the bright object a black elliptical shadow was seen. It resembled a crater, and measured about two miles in diameter. To the northeast and north extended a large white area. This was confirmed upon August 3d. The object coincides approximately in position with craterlet No. 3, "Harvard Annals," XXXII, Plate X. A telegram dated August 22d confirms the reality of a conspicuous change in this region since last month. It states that the existence of the new craterlet is confirmed, that its diameter is three miles and that the bright area had shifted obviously since August 3d. Several other objects not previously mapped have been observed while examining Plato. They consist of two craterlets and a dark spot between two rifts on the southern border of the crater floor, a large craterlet on the northeastern border and another one 2 sec. southeast of craterlet No. 68. The white area formerly so conspicuous surrounding craterlet No. 54 has almost disappeared.—*Scientific American.*

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## STEEL TIES AT HOMESTEAD STEEL WORKS.

For some months past the Carnegie Steel Company has been making railroad steel ties in an experimental way at the Homestead Steel Works. Recently a cheaper method of rolling these ties has been found, and the prospects are that the tonnage will be materially increased. The large amount of electric railroad building has proved a good consuming field for the railroad tie. During the coming winter it is expected that the output of steel ties at the Homestead Steel Works will be materially increased.

# The Jones Underfeed Stoker.

[*Report of the Franklin Institute, through its Committee on Science and the Arts, on the invention of Evan William Jones.*
*Sub-Committee: Kern Dodge, Chairman; John W. Hartman, James Christie, H. F. Colvin.*]

[No. 2283.]

The Franklin Institute, acting through its Committee on Science and the Arts, investigating the merits of the "Underfeed Stoker," by Evan William Jones, of Portland, Oregon, reports as follows:

Mr. Evan William Jones, while working on the problem of successfully burning Oregon fir, invented the first form of the device under consideration. The Oregon fir is extremely difficult to burn on account of its retention of a large proportion of moisture, and he found that this trouble could satisfactorily be overcome by supplying the wood from the bottom, thereby using the green fuel as grate bars for the pieces in combustion.

The first arrangement built by Mr. Jones was hand-operated, and the sticks of wood, in standard lengths of about 4 feet, were forced in by means of a system of levers. In this way the fundamental principle was proved to Mr. Jones' satisfaction to be correct, but the hand device was not an economical way of charging the furnaces, so he adopted the steam cylinder and ram for forcing the wood into place. The device proved entirely practicable, and was used successfully in a number of plants in Portland and vicinity for a number of years. These wood-burning grates were first operated about the year 1889. Not long after their successful operation it occurred to him that the field for a mechanical stoker, designed solely for the use of wood for fuel, was very limited, and, on account of high proportion of volatile matter obtained from bituminous coal, he turned his attention to the perfection of a mechanical stoker, using coal as fuel.

He was convinced that the fundamental principle of underfeeding was a success, and that the introduction of

the air above the fresh, or green, coal, but below the incandescent bed of fuel, would give a thorough mixture of the gas and air before reaching the zone of combustion, as the gases are driven from the green coal at about this point. This results in a practically complete combustion and the utilization of the heat of these gases, which in hand-firing is, to some extent, lost. At about this time permission was granted by the authorities of the Portland Cable Railway Company, Portland, Oregon, to equip two of their furnaces with this type of stoker, these being the first, using coal as fuel, to be put in practical operation. Several improvements and developments have since been made, but the fundamental principles were all set forth in these two stokers.

The coal in the underfeed type of stoker is thoroughly coked before it reaches the zone of combustion, and it is interesting to note, in this connection, that in the history of mechanical stoking attention was first called to the use of the progressive burning of coal by James Watt. He distilled the coal on a dead plate at the mouth of the furnace, and then pushed the coke back over the grate area by hand. In this way fairly good combustion can be obtained, but the labor is excessive. The first mechanical stoker was patented in 1841, by John Jukes, an English inventor. This was of the tread-mill type, now known as the chain-grate stoker, there being several makes on the market to-day of this general type.

In the Jones stoker the coal, being forced in below the bed of fire, causes the entire bed to move with each charge, so that the fresh coal is continually breaking up the surfaces of the bed, and tending to build the mound higher, causing the clinker and ash to roll off the top of the burning mound to dead plates on the sides, where they can be removed from fire doors at convenient points.

With certain grades of coal (the so-called fusing or clinker kind) trouble has been experienced in some stokers in the handling of the clinkers; but where such coal is to be had, good results can generally be obtained by mixing the coal with some other good kind, the percentage of good coal required being, as a rule, comparatively small.

Many objections have been raised to stokers in general on account of their not being able to respond quickly to variable loads, but we do not find ground for these objections in the underfeed type, where the forced draft may be increased, and the stoker operated more rapidly at will. In many cases this is taken care of automatically by the engine which drives the blower and operates the stoker valves, as the engine can be equipped with a regulating throttle valve, so that with a decreased steam pressure an increased amount of steam is allowed to pass to the engine, thereby increasing the blast pressure as well as the speed of charging the fuel. If the stokers are properly operated, no trouble should be experienced in regard to taking care of variable loads, as has been definitely proved by many users.

There have been many so-called total failures of mechanical stokers and, of course, there have been many invented which were not at all practicable, but many times stokers are condemned on account of matters which have no bearing on their construction or operation. Stokers have, in some instances, been condemned when the only trouble was that the fire did not have the proper draft on account of a stack insufficient to give ample draft, or a flue so constructed that the draft is almost entirely shut off. We have heard of one instance of stokers condemned because the damper lever on the flue was not placed parallel with the damper, so that the draft was cut down by having the damper partially closed. When stokers fail to operate properly, all these details should be looked into before they are condemned. In many cases the stoker is placed too close to the boiler tubes and the gases do not have sufficient time to properly ignite before they are chilled by coming in contact with the tubes.

The above is, of course, quite general, but we will now turn to the details of the apparatus under consideration.

*Fig. 1* illustrates the stoker complete with the steam cylinder and ram, coal hopper, retort and all the details which go to make up a complete device.

This view shows the pusher rod extending from either

end of the retort and its connection with the ram and steam valve shown beneath the hopper. This pusher rod will be better seen in the next illustration.

*Fig. 2* clearly shows the position of the tuyere blocks in relation to the retort, and also the pushers and pusher

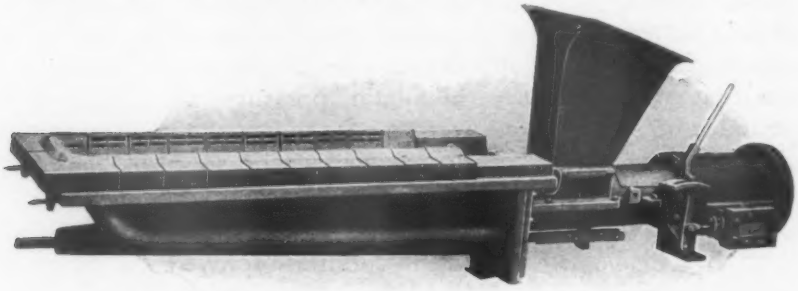

FIG. 1.—Jones under-feed stoker complete.

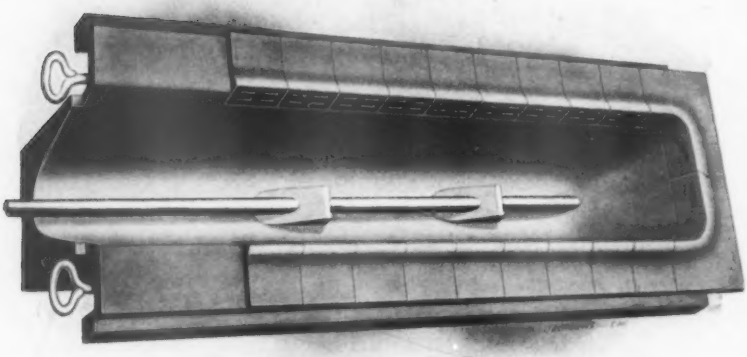

FIG. 2.—Retort of Jones under-feed stoker showing pusher rod and tuyere blocks.

rod in the bottom of the retort. The object of these pushers is to aid in pushing the coal to the rear of the retort, so that the entire bed will rise evenly. The position of the pushers can be adjusted, as well as the stroke of this pusher rod, independently of the length of stroke of the ram, which is

always operated at full stroke. In the illustration there will be seen, on the left, two handles; these are rods which lock the tuyere blocks into place. The scheme of fastening is better illustrated in the next cut.

*Fig. 3* shows the under side of one edge of the retort with some of the tuyere blocks in position and others which are not. The tuyere blocks are locked in position by the rod which runs through the lower projection on each. By withdrawing this rod all the tuyere blocks are loose and may be removed. It is not necessary, however, to renew these blocks often, and we have records of instances where

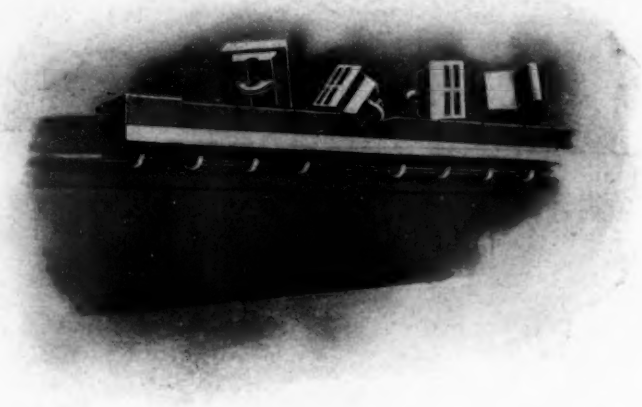

FIG. 3.—Method of attaching tuyere blocks.

they have been in continual use for long periods without being seriously impaired.

*Fig. 4* shows the part of the device which is outside of the boiler front. The retort, tuyere blocks and parts illustrated before, are, of course, on the inside of the boiler front under the boiler. The outside parts consist of a steam cylinder, ram case and ram for the coal, and a hopper from which the coal flows by gravity into the ram case. This hopper may be filled by hand or coal may be delivered to it by means of chutes from overhead coal bins, depending upon local conditions. Beneath the ram case the outer end

of the pusher rod may be seen; at this point it is separated into two plates with a series of opposite holes in them. A projection from the ram through the bottom of the ram case

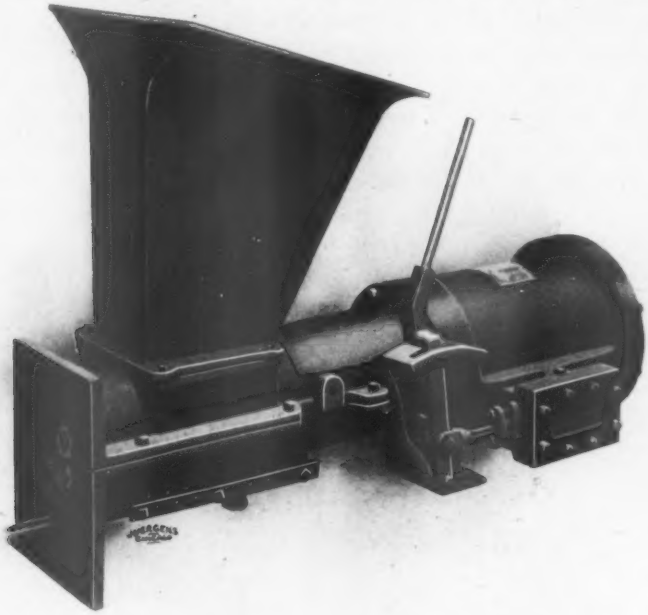

FIG. 4.—Cylinder, ram case and hopper.

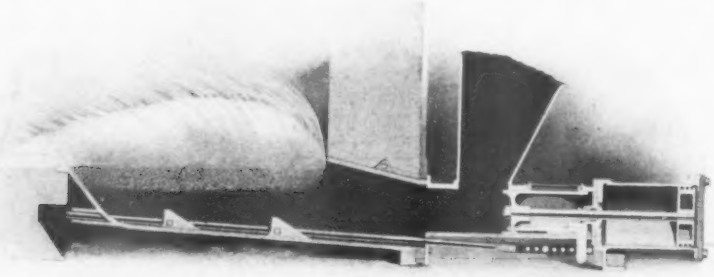

FIG. 5.—Jones under-feed stoker in operation.

engages the pusher rod by extending between the two plates which are attached to the pusher rod. The position of the bolts in the holes of these two plates determines, necessarily, the length of stroke of the pusher rod, as the projection

from the ram can travel between these two plates until it strikes the bolt which has been set in any desired pair of

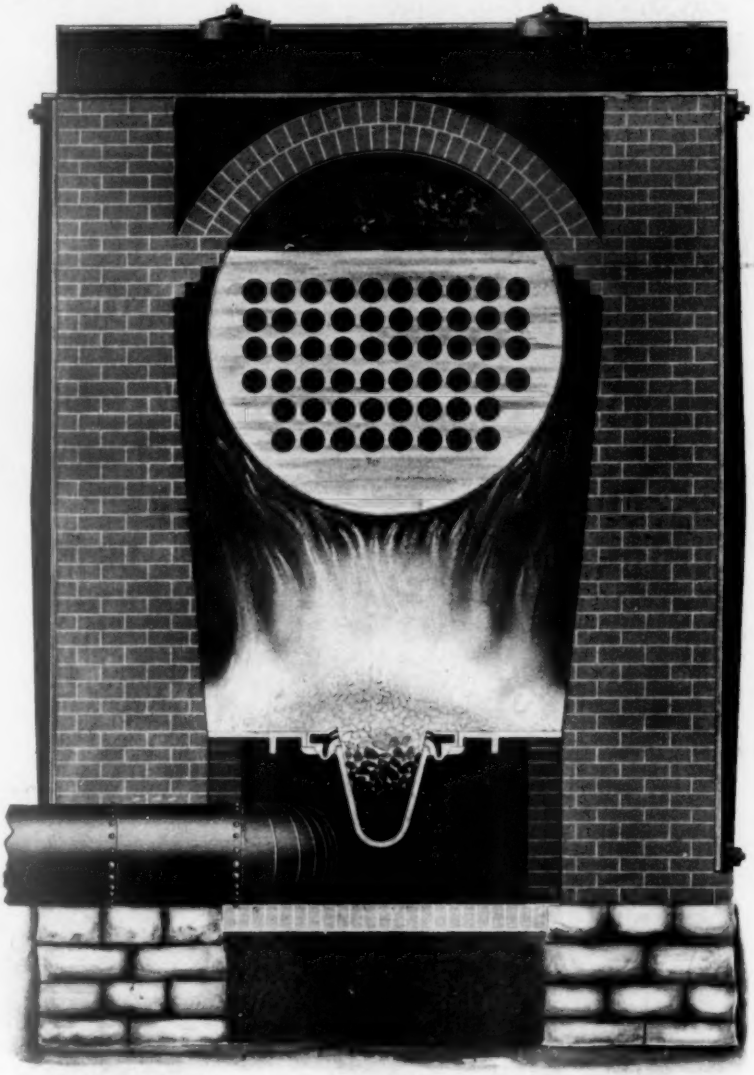

FIG. 6—Cross-section of boiler and stoker.

holes. The ram is operated in this case by hand, the handle being clearly shown. To this handle is attached the valve stem of the steam chest on the cylinder, and the *D*

slide valve is moved across the ports by this hand lever, thereby admitting steam to the cylinder at either end.

*Fig. 5* illustrates the completc stoker installed and in operation, showing clearly the position of the various parts and their relation to each other. The coal ram and the steam piston are connected to a common piston rod, as shown, and the arrangement is in all respects extremely simple. By moving a bolt, the stroke of the pusher-rod may be varied. The mound of incandescent fuel is shown above the retort.

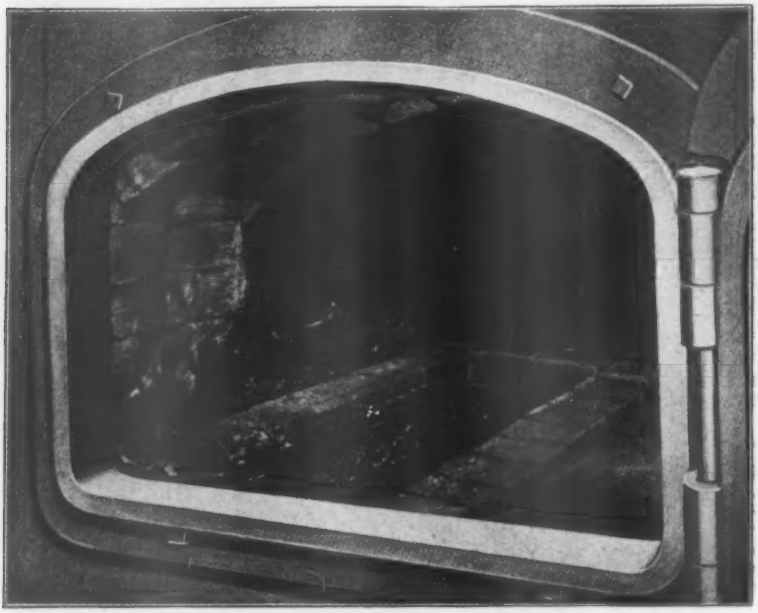

FIG. 7.—View through fire door showing retort.

*Fig. 6* shows a cross-section of a return tubular boiler with stoker in operation. This illustration shows the blast pipe from the low pressure blower at the bottom, opening into what would be the ash space if the boiler was hand fired, and the relative position of the tuyere blocks, green coal and incandescent bed of fire. The dead plates are seen on either side of the retort.

*Fig. 7* is a view is taken through the fire door of a boiler showing a retort which has been in operation. The coal

has been removed so that the tuyere blocks and their condition may be seen.

In *Fig. 8* will be seen five boilers in the plant of the Milwaukee Street Railway and Lighting Company, each

FIG. 8.—Milwaukee street railway and lighting company's boiler plant.

equipped with three Jones stokers. This particular installation is operated by an automatic device which is of the same principle as that illustrated by *Fig. 10.* The steam and oil cylinders are enlarged so that a single attachment is of sufficient capacity to operate three stokers instead of

one. This is accomplished by means of a shaft connected by a bell-crank to the piston of the automatic attachment. In this plant are seen the coal chutes for charging the stokers and the coal hoppers overhead; by this means all

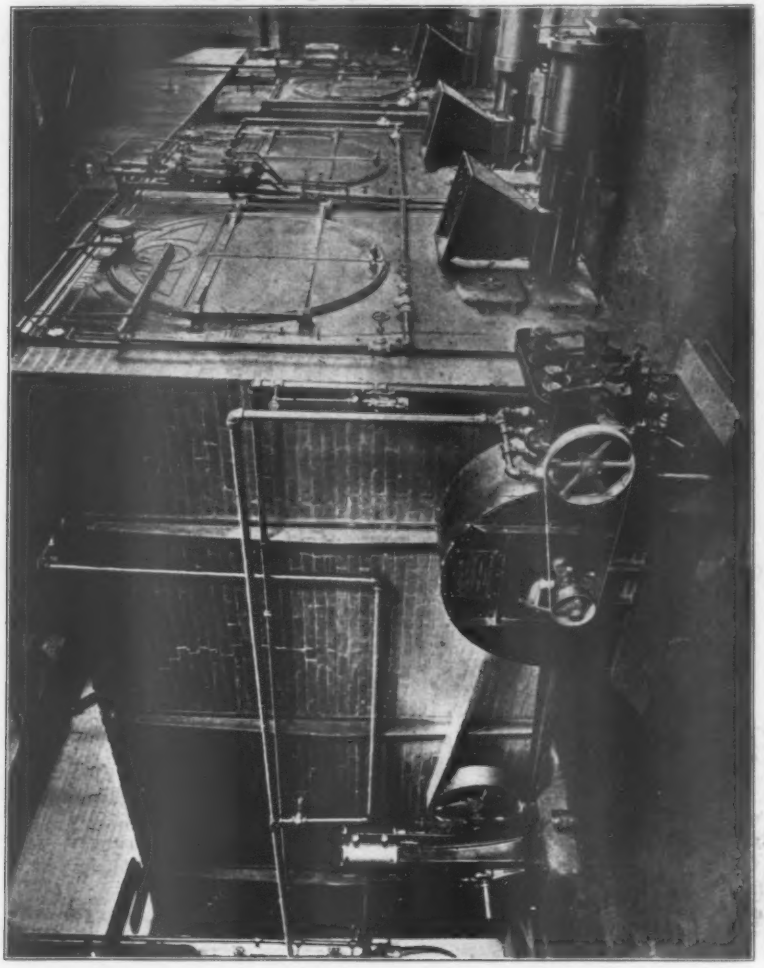

FIG. 9.—Engine blower and Cole automatic.

handling of the coal by hand is done away with, and considerable labor is thus saved.

On the right-hand side of *Fig. 9* the stokers are seen installed, and it will be noticed that they have no steam chests on their cylinders. In the center of the picture is

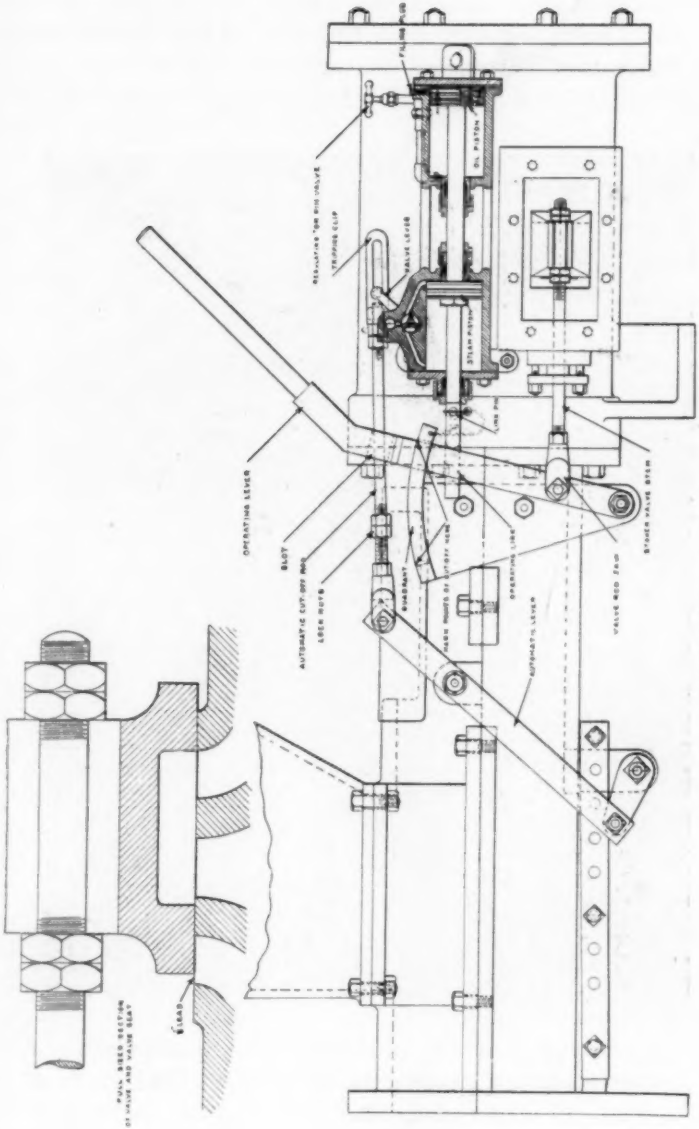

FIG. 10.—Automatic pump attachment on stoker.

FIG. 9.—Engine blower and Cole automatic.

the blower; directly in front of it is the automatic device which operates the stokers. This device is operated by a belt to the blower shaft, as shown.

It will be noticed that near the top of this device and on the front there are four gear-wheels with a *T*-slot groove across their faces and *T*-head bolts, which can be locked in

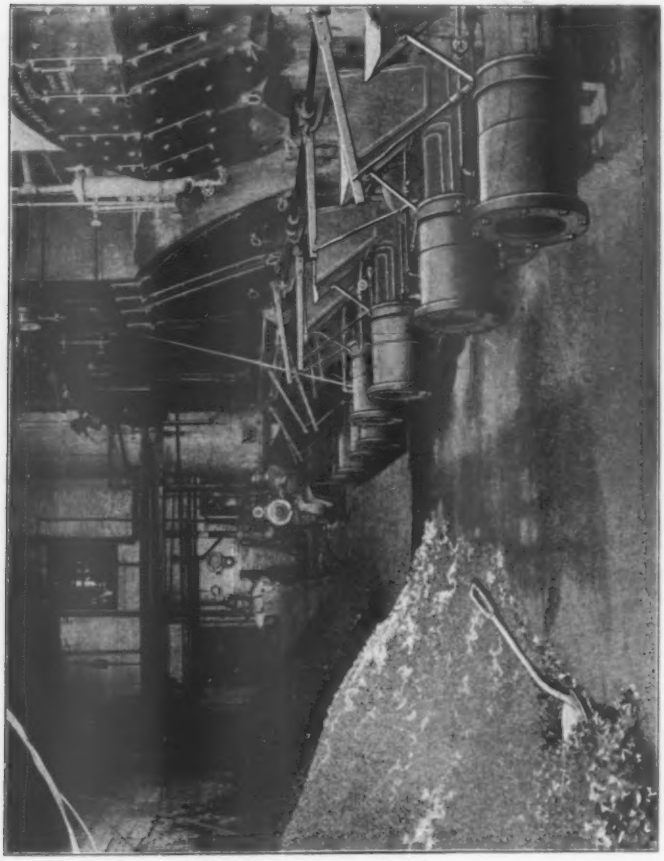

FIG. 11.—Jones stoker showing automatic crank shaft operating device.

this slot by means of the hand-wheel. On the shank of this bolt connecting rods are attached, which lead down to the valves below. Each of these valves control one stoker, and the valve, in making a complete cycle, alternately forces the ram of the stoker in and back to its charging position. The

amount of throw on these valves can be regulated by adjusting the *T*-head bolt in the slot of its gear, and the speed of the entire system is varied according to the speed of the engine, which is, in turn, controlled by the pressure of the boilers.

In *Fig. 10* there is a small independent pump attached directly to the stoker cylinder, which has a steam end and an oil end. The steam is admitted alternately on one side and then on the other of the steam piston, and the speed of this piston is regulated by a by-pass valve on the

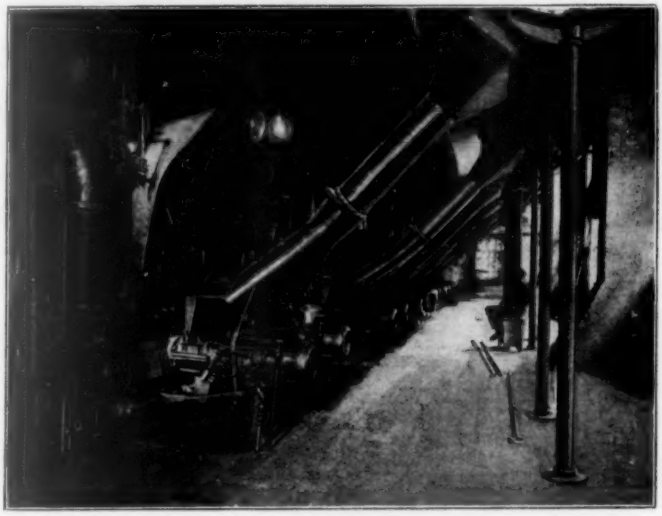

FIG. 12.—Eccentric shaft operating stokers.

oil cylinder. The piston rod of this pump engages the hand-lever of the stoker, and operates it in the same manner as it would be operated if by hand. The speed then of charging is regulated by the small by-pass valve on this independent pump.

We have in *Fig. 11* the boiler-room of the Bausch & Lomb Optical Company, Rochester, N. Y., and, as will be seen, there is a crank shaft across the front of the boilers and connecting rods from the various cranks to the operating handles on the stokers. The coal in this plant is shoveled by hand into the hoppers of the stokers, as shown.

In illustration *Fig. 12* the stokers are shown operated by means of a shaft beneath the ram case, which has eccentrics on it at each stoker. To these eccentrics connecting rods are attached to the hand operating levers of the stokers.

In *Fig. 13* the stokers are installed without any automatic operating device, being operated by the hand lever on the side of the stoker.

In the automatically-operated stoker installations it is possible to operate any one of the stokers independently by hand in case more coal is needed, so that the flexibility of the general system is not impaired by the installation of automatic devices. The general efficiency is, as a rule, slightly better where the automatic devices are employed, as the coal is fed regularly to the fires and the green fuel has time to coke before being forced into the zone of combustion.

It is also true that there is less smoke with an automatically-operated stoker than with the hand-operated. This would not be true if the hand-operated stoker was given the same number of charges, and at equal intervals, as with the automatic device, but where they are hand-operated the operator usually makes three or four charges in close succession and then passes on to another boiler to do the same thing. When the fires are stoked in this way slight smoke can be detected, which indicates, of course, incomplete combustion.

The Committee has had the opportunity of seeing many of these stokers in operation—both hand operated and with the various types of automatics in use. They found, however, that better results were obtained in some plants than in others, due entirely to the way they were operated, but, of course, this is true of any device which depends upon man, in any way, for its operation.

The Committee visited the plant of the Peerless Rubber Company, New Durham, for the purpose of investigating the stokers under consideration.

There are two boiler rooms at this plant, each having four Jones stokers in operation. The west boiler room has four stokers which are actuated mechanically by means of

a horizontal shaft running across the front of the boilers with an eccentric at each stoker, from which a connecting rod is attached to the hand-operating lever of the stoker.

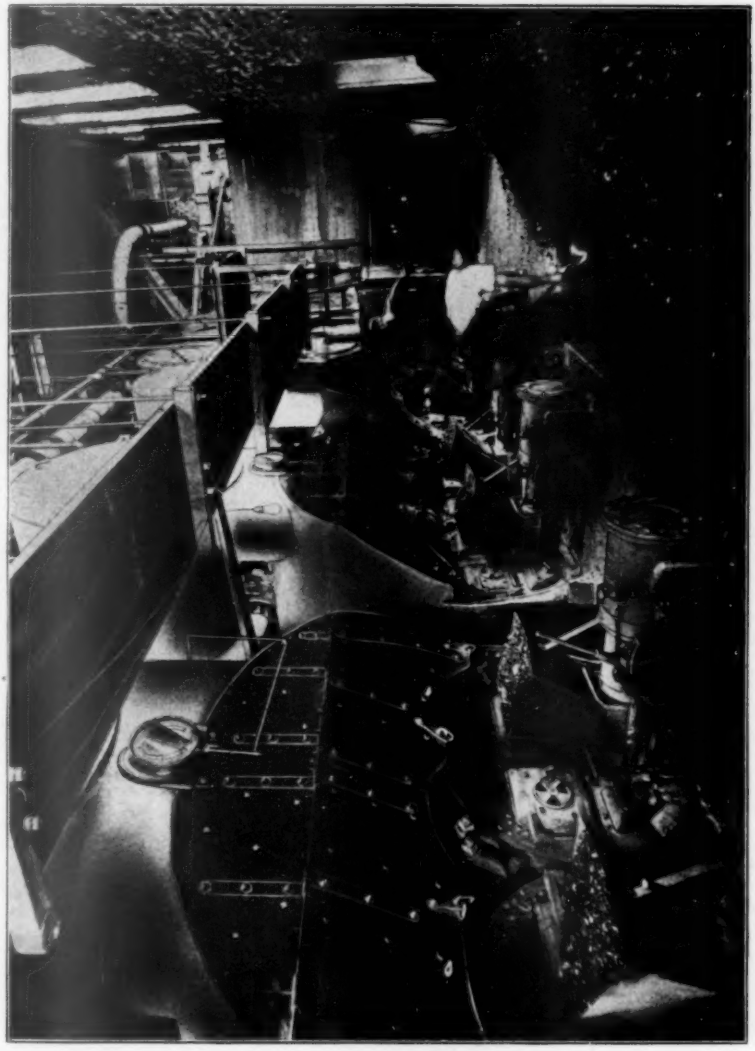

FIG. 13.—Hand-operating stokers.

Such an arrangement is shown in *Fig. 12*. This horizontal shaft is driven by the blower engine (which is a 5 horse-power Case engine) belted to a Sturtevant blower. By this

arrangement the boilers may be run to their utmost by simply regulating the speed of the blower engine. These stokers worked well and the fire was very hot and easily taken care of. We saw one of the fires cleaned, which had been running six hours, and the clinkers and ash which were removed would scarcely fill two shovels. There was practically no combustible left in the clinker or ash removed.

The coal used in this plant is a good grade of bituminous and is shoveled into the stoker hopper by hand. There was no smoke emitted from the stacks. One of the boilers was shut down for cleaning after about a year's run. The fire brick in the furnace was not badly burnt and no repairs in this respect were necessary. On the lower side of the lower tubes there was a deposit of a rather rough, lumpy character, possibly ¼ inch thick. This, however, did not extend to any of the tubes above the lower row and was not difficult to remove.

In the east boiler house at this plant there are four stokers of the automatic type with an actuating cylinder attached to the side of the main stoker cylinder, as shown in *Fig. 10*. These stokers worked very well, but there seemed to be some uncertainty about regulating them as to the speed of charging, and in this boiler house we found some combustible in the ash; also a slight amount of smoke was emitted from the stacks, from time to time, due, however, to the inefficiency of the man in charge. In cleaning the fires he drew out some coke and used the poker considerably, which added to the smoke and was entirely unnecessary.

The blower engine in this boiler house was also of 5 horse-power capacity, and during the noon hour the engines were run very slowly, thereby reducing the blast. Also, several charges of coal were forced in which reduced the heat of the fire very rapidly and placed it in a banked condition. The fires are from 12 to 18 inches thick and it is necessary to have the boiler set well above the fire on this account in order to give the gases sufficient time to properly ignite. The distance between the stoker and lower tubes of the boiler should be 4 feet, or thereabouts.

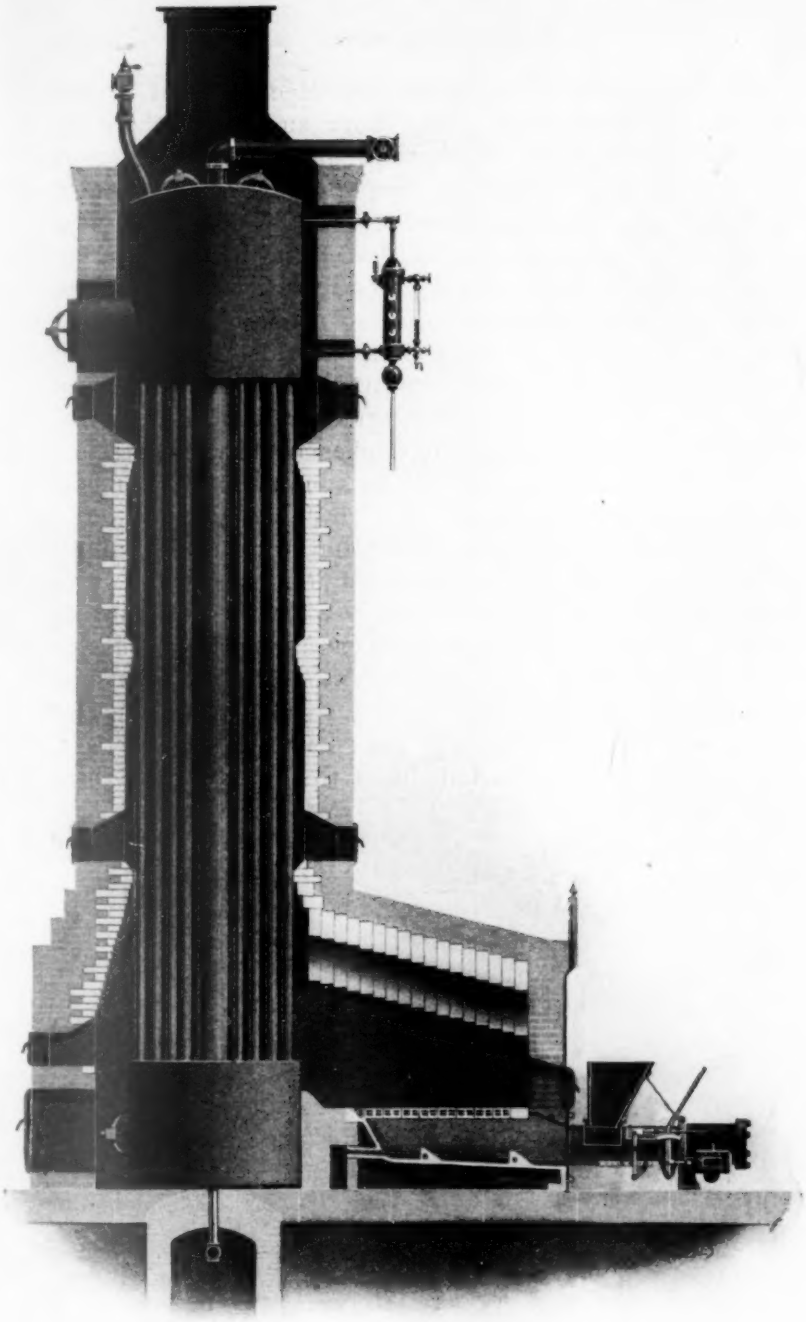

FIG. 14.—Jones stoker under Cook boiler.

The Committee also visited the Hecker plant of the National Biscuit Company, New York, and found there six hand-operated stokers which were firing about thirty-six tons of coal every twenty-four hours, with but one man in the boiler-room. The coal used is a good grade of bituminous slack, and no smoke was emitted from the stack except when the fireman was charging, and then it was very slight. No doubt there would have been no smoke at all had the plant been operated mechanically, as in this case the stoker might take, say, one stroke a minute, while in the case of hand firing the man might wait three or four minutes and then give the stoker as many strokes in close succession, thereby forcing a comparatively large amount of green coal into the fire.

These boilers were being forced and were running night and day. The fires were cleaned but once every twelve hours and sometimes a few clinkers were removed during the day, in case they became large enough to interfere with the fires. Before these stokers were installed the plant had been shut down on many occasions on account of lack of steam, but no trouble is now experienced in this regard. The coal in this plant is fed direct to the stokers by bins and chutes overhead.

The following plants have been visited and a total of thirty-nine stokers have been seen in operation:

The Dominion Wire Company, Montreal.
The Dominion Bridge Company, Montreal.
The Locomotive Machine Company, Montreal.
Grand Trunk Railway, Montreal. (Heating furnaces.)
Place Viger, Montreal.
Eastman Kodak Company, Rochester.
Peerless Rubber Company, New Durham.
National Biscuit Company, New York.
American Bridge Company, Philadelphia.

It will, no doubt, be of interest to see illustrations of applications of this stoker under various types of boilers which are shown herwith.

*Fig. 14* shows a hand-operated Jones stoker installed in section of a Cook boiler.

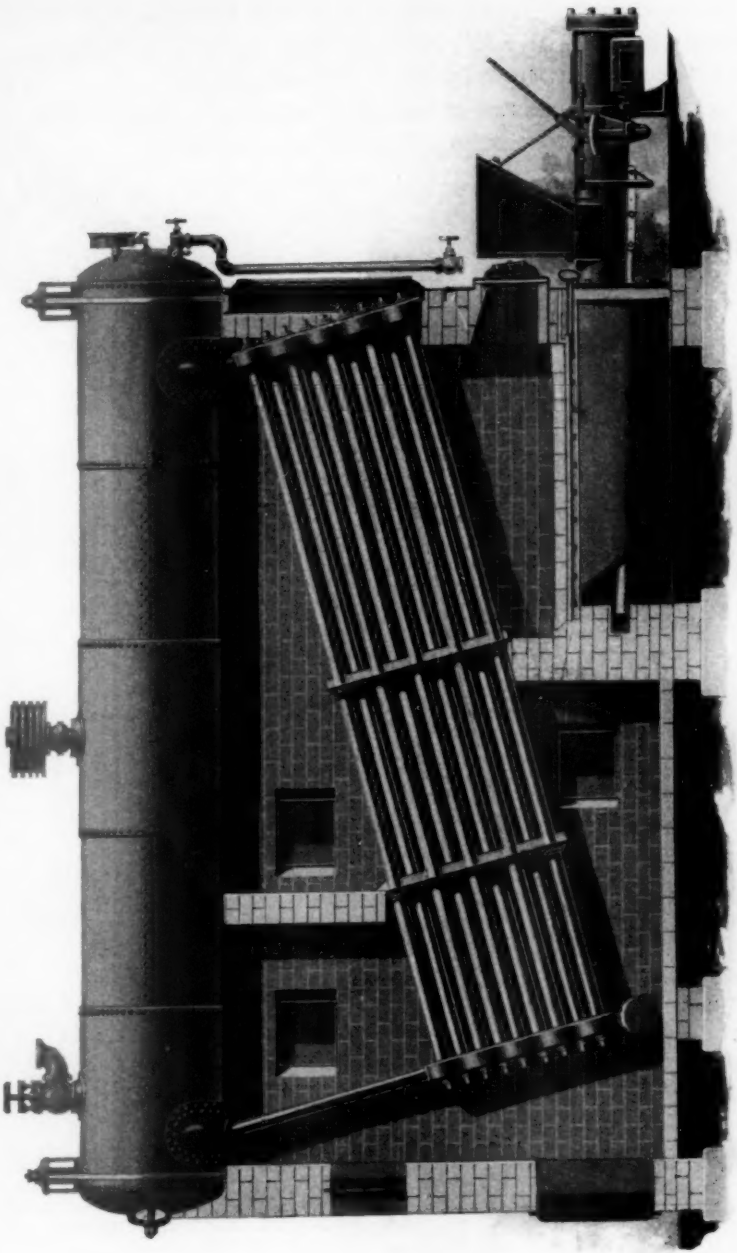

FIG. 15.—Jones stoker under B. & W. boiler.

*Fig. 15* shows a Jones stoker installed under a B. & W. boiler with the near wall broken down so that the interior may be seen. Further comment is unnecessary.

*Fig. 16* is a Jones stoker installed under a Stirling boiler, which shows the general application in this case.

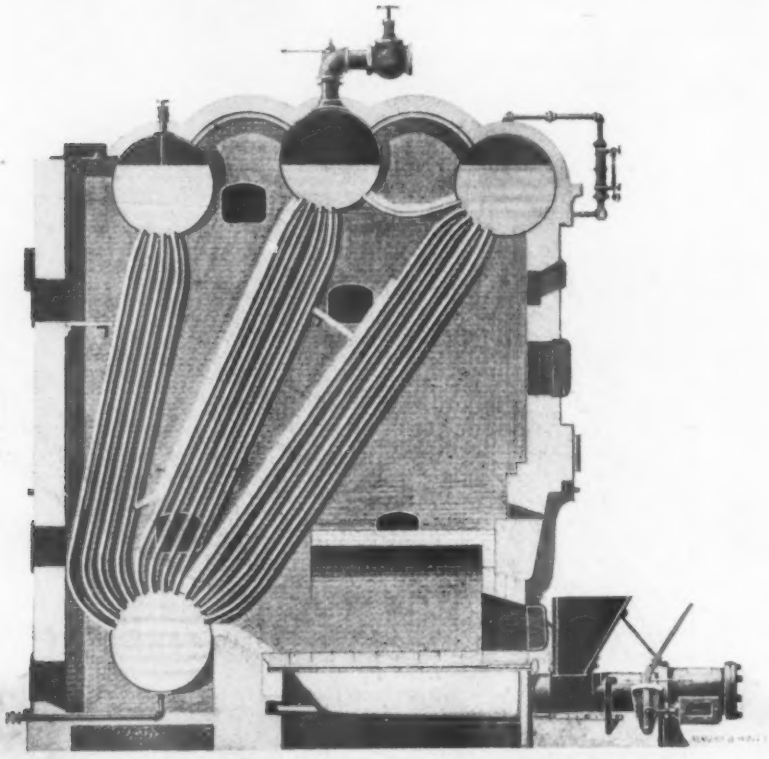

FIG. 16.—Jones stoker installed under Stirling boilers.

As to the matter of efficiency, we append several tables showing tests and data relative to the performance of these stokers.

Table 1 is compiled by the Portland Cable Railway, Portland, Ore.

TABLE I.

THE FIRST "COMMERCIAL" COMPARATIVE TEST BETWEEN UNDERFEED STOKING AND HAND-FIRING.

OFFICE OF PORTLAND CABLE RAILWAY.

PORTLAND, ORE., March 7, 1892.

DEAR SIR.—The following table will no doubt be of interest to you, as it shows the difference between hand firing and firing with the Jones Mechanical Stoker.

| *Mechanical Stoker.* | | *Hand Firing.* | |
|---|---|---|---|
| February 22, | 13,940 pounds. | February 29, | 17,680 pounds. |
| " 23, | 13,600 " | March 1, | 15,640 " |
| " 24, | 13,260 " | " 2, | 17,850 " |
| " 25, | 13,260 " | " 3, | 22,950 " |
| " 26, | 12,920 " | " 4, | 15,300 " |
| " 27, | 13,600 " | " 5, | 18,700 " |
| " 28, | 13,600 " | " 6, | 18,360 " |
| Total, | 94,180 " | Total, | 126,480 " |

Hoping that you can see the difference without having to put on your glasses, I remain, Yours respectfully,

R. A. MCCLELLAN, Chief Engineer.

These figures were taken at a time when slack and screenings were used in both furnaces. While firing with hand it was impossible to keep up steam, the road being shut down for want of steam at least once a day, every day during the time the hand-fired furnaces were in use. Upon one day (March 3d), five times.

With the stoker, sufficient steam was at all times furnished to operate the road. Saving in fuel, 25·6 per cent.

TABLE II.

STATEMENT OF A COMPARATIVE EVAPORATION TEST (HAND FIRING AND JONES UNDERFEED MECHANICAL STOKERS) UNDER 72-INCH R. F. TUBULAR BOILERS, IN "LAKE SHAFT" PLANT OF THE CLEVELAND IRON MINING COMPANY, ISHPEMING, MICH. ACTUAL COST OF OPERATION OF STOKER GIVEN.

| *Points Observed.* | *Hand Fired* | *Stoker Fired.* |
|---|---|---|
| Date of test | October 30, 31, | Nov, 1,2, 1895 |
| Coal used | Bit. Slack | Bit. Slack. |
| Duration of tests, *continuous hours* | 72 | 72 |
| Average steam presssure (gauge) | 118·95 | 118·95 |
| Average temperature feed water | 210 | 41·1 |
| Number of boilers in use | 2 | 2 |
| Total pounds coal consumed | 50,600 | 54,864 |
| Total pounds ash and clinker | 8,245 | 8,202·5 |
| Total pounds combustible | 42,354 | 46,661·5 |
| Per cent. ash and clinker | 16·27 | 14·9 |

| | | |
|---|---|---|
| Total pounds water evaporated | 312,323 | 341,483 |
| Pounds water evaporated per pound coal at observed temperature | 6·17 | 6·23 |
| Pounds water evaporated per pound coal from and at 212° | 6·45 | 7·57 |
| Pounds water evaporated per pound coal at observed temperature | 7·3 | 7·32 |
| Pounds water evaporated per pound combustible from and at 212° | 7·709 | 8·91 |
| Gain in evaporation | | 17·37 p. c |

NOTE.—Pounds coal consumed in stoker-fired boilers *includes* amount used in fifth boiler to make steam to run blower engine and stoker cylinder. Water evaporated in fifth boiler *not* being included.

This test is a comparative evaporation test, and shows a gain of 17·37 per cent. in favor of the stoker.

TABLE III.

REPORT OF TEST FOR CAPACITY MADE BY TORONTO STREET RAILWAY, TORONTO, ONT., WITH SCOTCH MARINE BOILERS, MECHANICALLY STOKED BY THE JONES UNDER-FEED STOKERS. MARINE BOILER 9 FEET 9 INCHES DIAMETER. TWO 39-INCH CORRUGATED FLUES. INCREASED BOILER CAPACITY 119 PER CENT.

| *Points Observed.* | *Scotch.* | *Scotch.* |
|---|---|---|
| Date of tests | Mar. 16, 1900 | Mar. 17, 1900 |
| Kind of coal | Pittsburg Mine Run | |
| Duration of test in hours | 5·5 | 9·2 |
| Heating surface in square feet | 1600 | 1600 |
| Grate surface in square feet | 39 | 39 |
| Average gauge pressure | 127 | 128·3 |
| Average absolute pressure | 141·7 | 143 |
| Average feed temperature, Fahrenheit | 142·2 | 143·8 |
| Average temperature of escaping gases, Fahrenheit, | 376 | 380 |
| Total amount of coal burned, in pounds | 7425 | 12497 |
| Total refuse | 558 | 1017 |
| Percentage refuse | 7·51 | 8·14 |
| Coal burned per boiler per hour, in pounds | 1325 | 1351+ |
| Coal burned per square foot of original grate surface per hour | 34 | 34·6 |
| Total weight of water fed into boiler at actual temperature of feed | 60215 | 100467 |
| Total equivalent from and at 212° F., fed into boiler and apparently evaporated | 67302 | 112151 |
| Equivalent hourly evaporation from and at 212° | 12054 | 12103 |
| Water actually evaporated per pound coal, in pounds | 8·11 | 8·039 |
| Equivalent evaporation from and at 212°, per pound coal | 9·064 | 8·974 |

| | | |
|---|---|---|
| Actual evaporation per pound combustible | 8·769 | 8·751 |
| Equivalent evaporation from and at 212° per pound combustible | 9·801 | 9·769 |
| Heat given to every pound of water to evaporate the same into steam at boiler pressure, B.T.U. | 1079·6 | 1078·2 |
| Heat transmitted to feed water per pound combustible | 9468 | 9136 |
| Horse-power developed (34½ pounds from and at 212°) | 346·5 | 350·8 |
| Rating of boilers (Builder's) | 160 | 160 |
| Water evaporated from and at 212° per square foot of grate surface | 7·534 | 7·564 |
| Heating surface per horse-power of 34½ pounds | 4·62 | 4·56 |
| Percentage increase in capacity over hand firing, taking Barrus test of August, 1895, as standard | 73 p.c. | 75 p.c. |
| Increase over Builder's rating | 116·6 p.c. | 119·2 p.c. |

Test given in Table III was made for capacity with Scotch marine boilers, 9 feet 9 inches in diameter, with two 36-inch corrugated flues. This test shows a very large increase in capacity over the builder's rating, as well as over the capacity when hand-fired in August, 1895.

TABLE IV.

TEST MADE UNDER ORDINARY WORKING CONDITIONS AT THE TORONTO ELECTRIC LIGHT COMPANY'S TERAULEY STREET STATION BETWEEN JONES UNDERFEED STOKERS AND HAND FIRING. TEST MADE AFTER FAILURE OF OTHER FURNACES TO SHOW ANY SAVINGS.

| *Points Observed.* | *Jones.* | *Hand.* |
|---|---|---|
| Date of test | September, 1897. | |
| Kind of boiler | Babcock & Wilcox, Water Tube, 212 H. P. | |
| Kind of coal | "Reynoldsville" Screenings. | |
| Duration of test, hours | 18 | 18 |
| Total coal burned in pounds | 13600 | 15000 |
| Total water evaporated, pounds | 126113 | 112338 |
| Average steam pressure, pounds | 158 | 158 |
| Average feed temperature, degrees | 145 | 145 |
| Actual evaporation per pound coal from temperature of feed water | 9·227 | 7·489 |
| Equivalent evaporation per pound coal from and at 212° | 10·3342 | 8·38768 |
| Relative evaporation | 123·2 | 100 |

Showing 23·2 per cent. increase in efficiency.

This test at Toronto Electric Light Company's Terauley Street Station shows an increase in efficiency of 23·2 per cent.

Of course, we all appreciate how difficult it is to obtain reliable data on boiler tests, but the showing in all cases with the stoker under consideration comes up so very well that it is only fair to assume that there must be considerable gain on all the points considered. We have records of many more such tests, but do not feel that it is advisable to embody them in the report.

In regard to patents, we find that the following bear on the subject in hand:

| | | |
|---|---|---|
| 409,792. | E. W. Jones | August 27, 1889. |
| 470,052. | " " " | March 1, 1892. |
| 470,053. | " " " | " " " |
| 569,207. | " " " | October 13, 1896. |
| 595,837. | J. M. Roe | December 21, 1897. |
| 464,664. | F. A. Daley | March 6, 1900. |

The first patent, No. 409,792, E. W. Jones, August 27, 1889, covers the fundamental principle of the stoker. We will quote some of his claims as follows:

(1) A furnace provided with a lateral fuel-supply opening beneath the fire, a supporting bottom for the fire, sloping upward and backward from the supply opening, grate bars forming a portion of said bottom, a dead plate forming the remaining portion of said bottom, and a ram on the side of the furnace for forcing fuel into the opening, whereby fuel may be readily pushed up into the fire and will be firmly supported independently of the position of the feeding mechanism.

(4) A furnace provided with a fuel chamber having an upwardly-inclined side and a fuel-supply opening below the line of fire, means for forcing fuel up into the chamber, and air-supplying grates in the side or sides of the chamber.

(9) In a furnace the combination of a fuel chamber having an upwardly-inclined bottom and a fuel-supply opening opposite said bottom below the line of fire, and a ram for forcing fuel into the opening, said ram having a fire-brick lining on the side entering the opening.

The second patent of Mr. Jones, 470,052, March 1, 1892, covers some of the details in the refinement of the apparatus, such as operating lever and valves, construction of ram and arrangement of air openings in the retort.

The third patent of Mr. Jones, 470,053, March 1, 1892, covers details in connection with the arrangement of grate bars for wood-burning, and is an improvement on his furnace 409,792. This patent, however, relates particularly to a retort having grate bars and taking air over the entire surface of it, while the later forms do not have this arrangement.

Mr. Jones' fourth and last patent, 569,207, October 13, 1896, relates to improvements in furnaces, with special reference to patents 409,792 and 470,053. He claims in this some slight improvements in shape of retort, such as flaring sides, etc. The arrangement of the valve-operating mechanism on the cylinder and the construction of the ram case, none of the changes being radical except the last claim, as follows:

(10) In an underfeed furnace with a fuel opening below the line of fire, a magazine gradually decreasing in depth toward the rear, and provided with a curved or inclined bottom and horizontally-attaching flanges to its upper edges provided with longitudinal slits to permit expansion and contraction, and an air-distributing pipe for forcing air over the top of the fire, and a ram or plunger for forcing the fuel into the magazine, substantially as described.

Patent 595,837, by J. M. Roe, December 21, 1897, relates to improvements in furnaces, and particularly to improvements in combination with an underfeed mechanical stoker of the type heretofore patented to Evan W. Jones in patents 409,792 and 470,052, to which this patent specifically refers. His patent covers the pusher bar with the pushers to aid in pushing the coal to the rear of the retort, making an even distribution more certain than by inclined hopper, as originally adopted by Mr. Jones. His patent also covers the system of varying the stroke of this pusher rod, as described in the early part of this report. It is an improvement on Mr. Jones' patents, and is not fundamental in regard to underfeed stoking or the design of stoker under consideration.

U. S. patent No. 464,664, to F. A. Daley, March 6, 1900, covers the details in connection with the tuyere blocks and

dead plates on either side of the retort. His first claim is as follows:

(1) In a furnace the combination of a fire-box of an elongated, horizontally-disposed fuel retort, dead plates upon each side of the retort, said retort and dead plates serving to afford a sealed space beneath the fire-box and retort, tuyere openings provided along the longitudinal sides of the retort, and affording communication between the fire-box and the space beneath the same and means for forcing air under pressure into the space beneath the fire-box, substantially as described.

In view of the fact that Mr. Evan William Jones has done such good work in bringing out the design of underfeed stoker under consideration, and in view of the simplicity of the device from a mechanical standpoint, both in construction and operation, we recommend that the John Scott Legacy Premium and Medal be awarded to him.

Adopted at the stated meeting of the Committee on Science and the Arts, held Wednesday, February 3, 1904.

Attest: WM. H. WAHL,
*Secretary.*

## MAGNETITE ARC LAMP.

C. P. Steinmetz has discovered that magnetite, the black oxide of iron, is suitable for use as an electrode in an arc lamp. From investigations which have been made with different materials, it appears that the arc flame issues from the negative terminal, and striking the positive produces heat. If the positive electrode cannot convey the heat away fast enough, it becomes hot, as in the case of the carbon arc. For this reason the flame-coloring substances are introduced into the positive electrode in the Bremer and other lamps. In the magnetite lamp the positive electrode is a copper segment, which is of such size that it does not get too hot, and therefore does not wear away, forming a permanent part of the lamp.

## EMPLOYEES IN THE KRUPP STEEL-WORKS.

United States Consul-General Richard Guenther, Frankfort, Germany, reports, under date of July 21st, that, according to the published statement of the Krupp Works, the total number of persons employed by the firm on April 1, 1904, including 4,190 officials, was 45,289. Of these the cast-steel works at Essen employed 25,041; the Gruson Works at Buckau, 3,329; the Germania shipbuilding yard at Kiel, 2,811; the coal mines, 7,877; the iron mines, etc., 6,231 persons.

## Obituary.

### THOMAS MESSINGER DROWN.

Thomas Messinger Drown was born in Philadelphia, March 19, 1842, and died in Bethlehem, Pa., Friday, November 18, 1904, in his sixty-third year. He was the son of the head of the firm of Drown & Co., the largest manufacturers of umbrellas in his native city, with an extensive shop in lower Market Street. He graduated at the Philadelphia High School in 1859, and from the medical department of the University of Pennsylvania in 1862, Prof. Robert E. Rogers having at that epoch the chair of chemistry in the medical course. He continued his studies in chemistry at the Sheffield Scientific School of Yale, and both at the Lawrence Scientific School of Harvard, and at the Boston Institute of Technology, for three years, finally passing the years 1865 and 1866 at the Academy of Mines in Freiberg, Saxony, and subsequently at Heidelberg.

The writer of these lines met him for the first time at Freiberg in 1866, and occupied the thoroughly student-like suite of a study and sleeping-room which Dr. Drown was just vacating.

The acquaintance begun in Germany ripened into warm friendship in this country on the present writer's return to Philadelphia in 1870, after four years passed in Germany and with Dr. Hayden's Geological Survey of the Territories. In 1871 Eckley B. Coxe, R. P. Rothwell, and Martin Coryell sent out a circular dated April, 1871, to numerous persons interested in mining and metallurgical affairs, which resulted in the reunion of twenty-two men, of whom Dr. Drown was one, at Wilkesbarre, Pa., on May 16, 1871. This was the foundation of the American Institute of Mining Engineers. In May, 1873, Dr. Drown was elected secretary of the Institute, and held the position till the annual meeting of 1883, fulfilling its duties in the most admirable manner. Previously to this, during 1869–70, he was an instructor in metallurgy at Harvard, and during his

early incumbency as secretary he maintained an analytical laboratory in Philadelphia, but in 1874–81 filled the chair of chemistry in Lafayette College, Easton, Pa. From 1885 to 1895 he was Professor of Chemistry at the Massachusetts Institute of Technology, and from 1887 in charge of the chemical department of the Massachusetts State Board of Health. In 1895 he was elected President of Lehigh University, which position he held till his death.

The above are the bare facts of Dr. Drown's career, from which, however, it is not difficult to conclude that he had in large measure those qualities which ensure their possessor "honor, love, obedience, troops of friends." The conclusion is amply justified, but it is not the whole truth. It is difficult to say whether Dr. Drown impressed one more by his gentle, courteous manner; his persuasive, low, musical voice; his constant good temper and fine sense of humor, or by his rigid scientific method of view; his exhaustive knowledge of the subject considered in his reports and lectures; and his clear exposition of them. Everybody was his friend. He had no enemies, and he deserved none. Without compromising his loyalty to a friend, he had that valuable faculty of evading dissensions, which was so noticeable in the late Dr. Joseph Leidy. But if he never aggravated an irritation, he succeeded very frequently in bringing peace and reconciliation to the heated disputants. Nothing unkindly ever passed his lips, but they uttered countless phrases of wisdom, wit and good will. Dr. Drown was, in the highest sense of the words, a thoughtful and profound scholar; a gentle, sympathetic and happiness-diffusing friend, and a Christian gentleman.

PERSIFOR FRAZER.

PHILADELPHIA, November 22, 1904.

# Notes and Comments.

## ARTIFICIAL COTTON IN FRANCE.

The French Chamber of Commerce of Milan says that an artificial cotton is now made from the cellulose of the fir tree freed from bark and knots. The fibers after being pulverized by a special machine, are placed in a horizontal brass lead-lined cylinder of some 3,500 cubic feet capacity and steamed for ten hours, after which 2,000 cubic feet of a bisulphate of soda wash is added and the whole is heated for thirty-six hours under a pressure of three atmospheres. Then the wood, or fibre, which has become very white, is washed and ground by a series of strong metallic meshes, after which it is again washed and given an electro-chemical bleaching by means of chloride of lime. Passing between two powerful rollers then dries the matter, producing a pure cellulose, which when reheated in a tight metal boiler containing a mixture of chloride of zinc and hydrochloric and nitric acids, to which is added a little castor oil, casein, and gelatine to give resistance to the fibre, gives a very consistent paste. Threads are then produced by passing this paste through a kind of draw-plate. These threads, after being passed over a gummed cloth, are immersed in a weak solution of carbonate of soda and passed between two slowly-turning drying cylinders. Finally, to give the necessary solidity, the thread is treated to an ammoniacal bath and rinsed in cold water, after which the product is pliable and works well.

In Bavaria experiments have recently been made to produce cotton from pinewood, and it is claimed that the trials have been very successful.—*Scientific American Supplement.*

## KAPOK AND ITS USES.

Every year that busy center of commerce, Amsterdam, receives nearly 1,000 pounds' weight of a curious and interesting vegetable substance known in Java and in the trade as kapok, which is found very useful for stuffing cheap mattresses and pillows among other purposes. It is a sort of yellow wadding which nature uses as a covering for the seeds of certain trees in the Malaccas, Its fibers being very non-resistant, it has been found impossible to spin or weave it, but it gives excellent results for bedding, making a mattress delightfully soft if it is exposed to the sun before being used. It is exceedingly light and buoyant, in this respect greatly surpassing cork, as it will support in the water thirty-five times its own weight. The tree whence it is derived (*Eriodendron*) grows rapidly, and in the second year is 12 to 15 feet high. but it does not fruit abundantly until the fourth year. Like the cotton plant, it bestows two gifts on man—the special wadding mentioned, which lines the husk, and the oil extracted from the seeds, which is used especially in the Chinese markets. The threads of the soft fiber taken from the pods are light yellow, rather silky, and only about an inch in length. They are made into thin rings. Kapok, it is said, never decays. Among the ever-increasing uses to which this curious vegetable product is put—causing the culture of the Eriodendron to make great strides in the Dutch Indies, while efforts are being made to cultivate it in similar climates—it has been suggested that excellent life-saving

apparatus might be made from it, which should be in the form of mattresses and cushions, easily obtainable in moments of danger. Three hundred grams of kapok (10¼ ounces) will support a man of 10 stone 5 pounds (145 pounds) in the water; and experiments by a French society with articles made of this wadding, which had previously been soaked in water for eighteen hours, gave excellent results. One small mattress supported several men. It is probable that soon all ships' beds will be made of kapok.—*Chambers's Journal.*

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## GARNET FOR ABRASIVE PURPOSES.

The use of garnet as an abrasive has found a flattering reception among manufacturers; and while it meets the competition of quartz, corundum, crushed steel, and carborundum, these materials have not limited or decreased its popularity. According to the report of Mr. Pratt in the Mineral Resources of the United States for 1902, the total value of all natural abrasives produced in the United States for that year was $1,326,255, and of this amount $132,820 was represented by garnet, as against $104,605 for corundum and emery.

Local shipping conditions influence the success of quarries of abrasive substances intimately. The Montana corundum deposits were practically shut out from the general market because of prejudicial freight rates. When these were removed, or modified, they began, in July, 1903, to produce raw material at the rate of from 800 to 1,000 tons per year.

Mr. Pratt says that in 1902 the production of corundum in the United States was almost entirely of the emery variety. It was confined to Chester, Mass., and Peekskill, N. Y., the latter locality greatly increasing its output. The Canadian corundum is very largely imported into the United States, and this importation quite steadily increases. The total amount of commercial corundum produced in Canada in 1902 was 1,611,200 pounds, valued at $88,616, or nearly $110 per ton. It, for the most part, leaves Canada, and the United States is her largest customer.

Garnet as an abrasive has a good market. New localities of this material of fine quality and in accessible situations cannot fail to attract notice and reward development. An apparently rich deposit of garnet has been recently brought into business prominence, which is located on little Pine Creek, Little Pine Creek Township, Madison County, North Carolina.

The garnets occur in a chloritic schist well developed and in large aggregates. They are the iron alumina variety—almandine—and not infrequently present superb gem surfaces, which furnish very superior cuttings.

The prospecting of this property began in January, 1904, and after the work of a month over 20 tons of good merchantable garnet was cleaned up. Work was resumed in March and continued for two months. In this period over 160 tons were mined and 140 tons shipped. The garnet is pronounced to be an excellent abrasive. The property promises important results, and will naturally attract some attention. The garnets resemble the famous Salida, Colo., specimens, and furnish attractive mineral groups.

The company now engaged in the exploitation of this property is the North Carolina Garnet Company, incorporated under the laws of New York State.

### ALUMINUM CONDUCTORS.

In a paper read before the Canadian Electrical Association, Mr. Roderick J. Parke contributes some valuable information relating to the use of aluminum for electrical conductors. As compared with copper, the cost of transportation and erection of aluminum conductors is less, the durability greater and the cost of maintenance less; but these advantages are counterbalanced by difficulty in making joints, great sag due to large co-efficient of expansion and insufficient strength of the wires in sizes ordinarily used for telegraph and telephone lines. The following data are of assistance in showing the relative merits of commercial aluminum and commercial (hard drawn) copper, of sizes ordinarily used for conductors:

| | Aluminum. | Copper. |
|---|---|---|
| Specific gravity | 2·68 | 8·93 |
| Conductivity | 62·00 | 97·00 |
| Tensile strength (per square inch) | 28,000 | 45,000 |
| Cross-section for equal resistance | 1·56 | 1 |
| Diameter for equal resistance | 1·25 | 1 |
| Weight for equal resistance | 0·47 | 1 |
| Tensile strength for equal resistance | 0·96 | 1 |

The difficulty of soldering aluminum is well-known, and, while it can be done, the operation is so difficult that in most cases unsoldered joints are preferable. For joining aluminum wires smaller than No. 0000 (B. & S. gauge), the two ends are inserted into a piece of flattened tube and the tube given 2·5 twists by means of two pairs of ordinary wire connectors. Larger sizes can be conveniently joined by means of the ordinary dovetailed splice, by means of terminals compressed on the ends at the factory, or by inserting the ends into a cast sleeve and compressing the latter in a portable press.

## Book Notices.

*Types and Details of Bridge Construction.* Part I. Arch Spans. Examples of constructed, wooden, combination, wrought iron and steel arches for highway and railroad bridges. By Frank W. Skinner, M. Am. Soc. C. E., etc., etc. 8vo, pp. 289. New York: McGraw Publishing Company. (Price, $3.00.)

The author explains in his prefatory remarks that his object has been to present in this work the development of advanced practice and its standard details, to illustrate the classes of structures adapted to different conditions, to show some of the characteristic differences between American and foreign design, and to illustrate some primitive or obsolete constructions, besides recording important and well-known examples so as to have their principal data easily accessible.

The subject is treated under the following heads: Part I.—Wood and Iron Arch Spans. Part II.—Spandrel Braced Arches. Part III.—Arch Trusses. Part IV.—Plate Girder Arches.

The work is elaborately illustrated, and is intended for students, instructors, designers, engineers, architects and contractors. W.

*Das königliche Material-Prüfungsamt* der Technischen Hochschule Berlin auf dem Gelände der Domäne Dahlem beim Bahnhof Gross-Lichterfelde, West. Denkschrift zur Eröffnung bearbeitet von dem Director A. Martens, Professor und Geheimer Regierungsrath, und M. Guth, k. Landbauinspector. Mit zahlreichen Textfiguren und 6 Tafeln. Large 4to, pp. 380. Berlin: Verlag von Julius Springer, 1904.

The above-named volume forms an imposing memorial of the opening of the splendidly-equipped Department for Testing Materials of the Technical High School in Berlin. Every branch of this extensive establishment is described and illustrated in elaborate detail. W.

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*Wireless Telegraphy;* its origin, development, inventions and apparatus. By Charles Henry Sewall. With eighty-five diagrams and illustrations. 8vo, pp. 229. New York: D. Van Nostrand Company, 1903. (Price, $3.00.)

This is a very timely publication, covering the history, systems, principles and possibilities of wireless telegraphy in theory and practice. The book is free from abstruse mathematics, and should be of service both to layman and student. W.

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*National Conference on Secondary Education and its Problems*, held at Northwestern University, October 30 and 31, 1903. Stenographic report of the proceedings, edited by V. K. Froula. Published by the University, Evanston, 1904.

This conference was called by Northwestern University to meet at Evanston, Ill., October 30 and 31, 1903. The meeting appears to have been a very successful one, there being present and participating representatives of twenty-five States.

The stenographic report of the proceedings of the conference, edited by Mr. Froula, makes an octavo volume of 256 pages. The scope and character of the discussions will be understood from the following list of subjects:

I. "What is the place and function of the endowed academy, or of the private high school for boys and girls in our present system of education?"

II. "What is the true function of the public high school?"

III. "What is the effect of the system of accrediting schools by the universities upon the high school and its development?"

IV. "What may the public high schools do for the moral and religious training of its pupils?"

V. "Some serious defects in our high school system."

VI. *a*. "Are there too many women teachers in the schools?"

*b*. "How may we counteract the growing encroachment of social life upon serious study?"

*c*. "How shall we remedy the tendency to imitate questionable features of college life, such as fraternities, excessive development of competitive sports, etc., etc."

VII. Addresses by Congressman Boutelle upon the "American High School as the Training Place for Citizenship," and by Professor Fisk on "Where to Place the Emphasis in Secondary Education." W.

# Franklin Institute.

[*Proceedings of the stated meeting, held Wednesday, November 16, 1904.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, November 16, 1904.

PRESIDENT JOHN BIRKINBINE in the chair.

Present, 160 members and visitors.

Additions to membership since last report, 10.

The chairman introduced Dr. Z. B. Babbitt, of the American Telegraphone Company, of New York, who read a paper describing the invention of Valdemar Poulson, of Copenhagen, Denmark, known as the "Telegraphone," by which the sounds of the human voice are recorded on a metal wire or disk—without indentation or mark of any kind—by electro-magnetic means, and may subsequently be reproduced audibly through the telephone an indefinite number of times with extreme fidelity, or, if desired, may be destroyed by similar means. The subject of the invention was, on motion, referred to the Committee on Sciences and the Arts for investigation and report.

Dr. Babbitt, at the close of the meeting, gave a demonstration with the machine.

Dr. Henry Leffmann, by special request, presented some interesting reminiscences of "Washington as an Engineer," and illustrated his remarks by exhibiting a series of lantern views of a number of drawings of land surveys, etc , made by Washington.

The thanks of the meeting were voted to the speakers of the evening, and the session was adjourned.

WM. H. WAHL,
*Secretary.*

## Committee on Science and the Arts.

(*Abstract of the proceedings of the stated meeting, held Wednesday, November 2, 1904.*)

PROF. LEWIS M. HAUPT in the chair.

The following reports were adopted:

(No. 2318.) *Suction Gas Producers:* Otto Gas Engine Company.

This apparatus apparently cannot be considered as a single invention, being, in fact, the completed result of a series of improvements made in the various branches of the extensive Otto Gas Engine Company.

The present invention is a simplified apparatus for making producer gas for use in gas engines. With this apparatus the use of a gas-holder is dispensed with, the gas being produced just at the rate at which it is needed. It consists substantially of a furnace or producer and a scrubber.

The lower portion of the producer contains the fire-box. The ash-box below the grate is enclosed so that the air can be admitted only through a passage to be described below. Air-tight doors permit of access to the grate for stoking, raking and removing ashes.

An annular water-jacket is placed above the fire-box, by which the gases

from the furnace are cooled before they enter the pipe leading to the scrubber. The jackets also serve to saturate the air with steam before it is led below the grate.

Above the jacket there is a coal magazine which is filled from time to time, and from which the coal passes through the central opening of the jacket as the coal in the fire-box is consumed. The cover of the magazine, which is practically air-tight, has a central orifice closed by a spherical valve through which a stoker can be thrust for the purpose of stoking the fire when necessary, practically excluding the air during the process.

The scrubber is a vertical drum filled with broken coke over which water is sprayed. The gas, passing upward through this, is cleansed of dust and of all admixed gases which are soluble in water, such as sulphuretted hydrogen that may form in the presence of sulphur in the coal.

From the scrubber the gas is led to the engine, where it is mixed with air, in the usual way, to produce the explosive mixture.

In starting the fire the combustion gases are led to the chimney, an artificial draft being produced by means of a fan driven by hand. After the fire is in proper condition, access to the chimney is closed and the gas is admitted to the scrubber. Raking and stoking should be done about every two hours. The air admitted to the fire through the ash-doors, while this is being done, has no noticeable effect on the quality of the gas. As this air is not saturated with steam, the gas then produced will, of course, be free from hydrogen, and will contain a relatively greater percentage of nitrogen.

For this reason the raking should be done without needless loss of time, and the doors promptly closed. A fresh fire is found to be advantageous about once a week to prevent the accumulation of clinkers. Over night the fire is maintained by banking and making connection with the chimney.

The report here gives the results of the test of one of these suction producers in the works of Hugo Bilgram, made by Messrs. E. B. Myers and H. D. Pratt, students at the University of Pennsylvania, under the supervision of Prof. H. W. Spangler.

From this test it appears that the coal consumption per indicated horse-power was 1·48 pounds, or, adding the proportional share of coal used to start the fire, 1·88 pounds per indicated horse-power. The test was made under rather unfavorable conditions. The mean performance during the test of engine, rated at 48 brake horse-power, if fed with producer gas, was only 25·3 indicated horse-power. Under these conditions it is obvious that the efficiency of the engine was not as high as it would have been had the engine been used more nearly at its maximum performance.

The committee concludes that the efficiency of the engine supplied with a suction producer is far higher than that of steam engines of equal power; and, since it also requires less attention, it seems to be the least expensive of the prime motors where natural agents, such as waterfalls or natural gas, are not available.

*Sub-Committee:* Hugo Bilgram, Chairman; J. M. Emanuel, John Haug.

(No. 2284.) *Wire-Testing Machine.* Falkenau-Sinclair Machine Company, Philadelphia.

ABSTRACT: The principal feature of this machine is the provision for conducting a bending test while the test-piece is subject to a tensile stress, which

enables the specimen to be tested under approximate working conditions. The usual method of determining whether a coil of iron or steel wire or cable comes up to requirements, after a preliminary examination of its size and general appearance, is to first ascertain its ultimate strength and elongation from test-pieces cut from each end. If the result is in accordance with requirements, a bending test is made, the test-piece being clamped between jaws and bent repeatedly through an arc varying from 90° to 180°. No tension is applied during bending, the number of bends that the wire is capable of withstanding without fracture determining the approximate quality of the metal.

A torsional test is frequently called for in specifications in which a certain specified number of twists are required in specified lengths; and not infrequently, other requirements are specified which are impracticable and inconsistent. All of which indicates the need of standard methods and improved apparatus for wire-testing purposes.

The report proceeds to say that the Falkenau-Sinclair machine is an advance step in this direction, though it is still open for improvement. Then follows a detailed mechanical description of the construction and operative features of the machine, which would not be intelligible without the aid of illustrations. Reference to the patent is made, to wit: Lee C. Moore, Brooklyn, N. Y.; U. S. Patent No. 673,526, May 7, 1900; and to the following claims of same, which will be generally explanatory:

"Claim I. In a metal-testing machine the combination of devices for applying tensile strain to the metal and for repeatedly bending the same in reverse directions while under tensile strain, and of devices for registering the extent of the stretch of the metal as strained and bent for the purposes set forth.

"Claim II. In a metal-testing machine the combination of two sets of jaws adapted respectively to grip the end of the metal being tested, one of the pairs of jaws being movable longitudinally away from the other pair, and the latter pair being pivotally supported at a point lying between the said pairs of jaws, an additional pair of clamping jaws adapted to clamp the metal when stretched between the said stretching jaws, and means to register the amount of strain applied to the metal by the stretching jaws, for the purposes set forth."

The report concludes in the following terms: "In view of the fact that Mr. Lee C. Moore has brought out a labor-saving device that is an improvement over other types in that the tensile and bending tests can be determined simultaneously under approximately working conditions, and in view of its simplicity of construction from a mechanical standpoint, we recommend the award of the John Scott Legacy Premium and Medal. (*Sub-Committee*, Kern Dodge, chairman; Charles E. Ronaldson.)

The following reports passed first reading:

(No. 2312.) *Cap-Screws and Bolts.* Cleveland Cap-Screw and Bolt Company, Cleveland, O.

(No. 2327.) *Glazier's Fire Nozzle.* Bradley & Munson, New York.

(No. 2331.) *Electric Protective Devices.* International Burglar Immunity Company, Philadelphia.

(No. 2350.) *Instantaneous Automatic Water Heater.* Rue Manufacturing Company, Philadelphia. W.

## Sections.

SECTION OF PHOTOGRAPHY AND MICROSCOPY.—*Stated meeting*, held Thursday, November 3d. Dr. Henry Leffmann in the chair. Present, 63 members and visitors.

Mr. John Bartlett, of Philadelphia, presented a paper on "Photographic Art and Motion." The speaker's remarks were profusely illustrated by the exhibition of a series of lantern photographs of famous pieces of statuary and paintings, as well as by views from nature. The speaker's contention was that by proper attention to correct rules of art, photographers might greatly enhance the artistic effect of their productions.

Dr. Leffmann followed with some informal, but highly interesting, remarks on "Washington's Work as an Engineer," which he illustrated by several photographs of survey maps, sketch maps and mathematical exercises, the originals of which, in Washington's own hand, are preserved in various collections.

Following the regular business of the evening, a communication was read from Mr. Walter Zimmerman, containing a proposition that the Franklin Institute inaugurate a system of collecting, cataloguing and preserving photographs of historic interest, in conjunction with the American Federation of Photographic Societies.

The Section voted to refer this communication to the Board of Managers of the Institute with a favorable recommendation, and the Executive Committee of the Section was directed to confer with the Board in the consideration of the subject.

The chairman thereupon adjourned the meeting.

M. I. WILBERT,
*Secretary.*

CHEMICAL SECTION.—*Stated meeting*, held Thursday, November 10th, 8 P.M., Dr. W. J. Williams in the chair. Present, 15 members and visitors.

The papers of the evening were as follows:

Dr. J. Merritt Matthews on "Sulphur Dyes."

Dr. E. Goldsmith on "Salt Making in the Far West."

Both were freely discussed, and will appear in due course in the JOURNAL.

W. E. RIDENOUR,
*Secretary.*

MINING AND METALLURGICAL SECTION.—*Stated meeting*, held Thursday, November 17th, 8 P.M. Mr. C. H. Clamer in the chair. Present, 29 members and visitors.

The chairman introduced Mr. Paul Kreuzpointner, Superintendent of Tests, Pennsylvania Railroad Company, Altoona, Pa., who read a paper on "Metallurgy in its Relations to Industrial Education."

Dr. Geo. P. Scholl gave a communication on "The Manufacture of Ferro-Alloys."

Both communications were freely discussed.

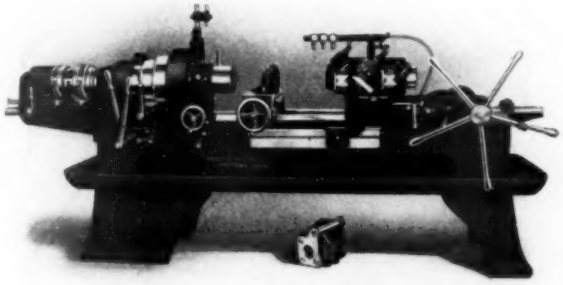
The chairman tendered the thanks of the meeting to the speakers of the evening.

WM. H. WAHL,
*Secretary pro tem.*

## Improved Machinery, Apparatus and Processes.

[This department will contain from month to month descriptions of new machines, apparatus and processes. The data, for which the editor must depend largely on information derived from interested sources, will be carefully edited. The Committee disclaims responsibility.—THE COMMITTEE ON PUBLICATIONS.]

The Pratt & Whitney 3 x 36-inch turret lathe, illustrated by accompanying engraving, will take rod work up to 3 inches in diameter and 36 inches long, and may be provided with chucks for short work of larger diameter. The chuck is arranged to handle stock $\frac{3}{32}$ of an inch oversize to $\frac{1}{32}$ of an inch undersize. This is accomplished by means of two levers, one which brings the chuck-jaws in contact with the stock and the other which clamps them on the stock, insuring a uniform clamping pressure. The power-rod feed mechanism has no delicate parts to get out of adjustment or mar the stock, and when the chuck-jaws are opened it advances the rod to an easy contact with the stock-



stop, which is attached to the head-stock. Each tool in the turret has a separate stop, carried in a bracket on the front of the bed, against which an arm traveling with the turret-slide, always comes to rest when the tool is moved forward. These stops are easy to adjust.

The double cross-slide is fitted with two tool-posts of special design and both the cross-slide and the turret-slide have four changes of positive power-feed in each direction. The handles for changing the feeds are conveniently located on the front of the head-stock. The double cross-slide has adjustment along the bed by screw and hand-wheel.

The turret tools are bolted to the broad faces of the heavy turret which supports them directly in the line of strain. In the illustration the machine is shown equipped with universal turners and end forming tool.

The tools usually furnished are: one or more universal turners, multiple turner, end forming and pointing tool, bell-mouth pointing

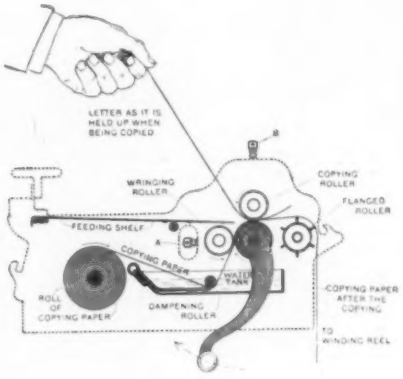
tool, taper turner. The spindle has double friction back gears which with three-speed countershaft gives 27 spindle speeds.

The Niles-Bement-Pond Company, 136 Liberty Street, New York, may be addressed for further information.

THE RAPID ROLLER LETTER COPIER produces without delay copies of pen and ink, indelible pencil or typewritten matter, showing in the copy the exact signature and all changes made in the original letter.

Two japanned cast-iron sides, connected by stay rods, support the feeding shelf, roll of copying paper, water pan and rollers.

As shown in accompanying illustration, the roll of tissue copying-paper, containing sufficient for 1,000 copies, passes into a removable brass nickel-plated water pan, beneath the dampening roller, then up




between the wringing and hard roller, where all superfluous moisture is removed. The wringing roller is adjusted by capstan-headed screws, with lock nuts, the adjustment being permanent.

From the wringing roller, the paper passes between the hard roller and compression roller, where the letter to be copied is inserted between the moist copy-paper and the compression roller. The latter is adjusted by means of capstan-headed screws with lock nuts, and is brought into action by means of a bar cam-lever acting on both end bearings simultaneously. After adjustment has once been made uniform pressure is always obtained by the lever, and with consequent uniform results.

The paper with the impression passes out over the radial flange roller, then down into the base, where it is drawn just sufficiently taut to dry smoothly, and is wound automatically on a metal reel.

The open base allows a free circulation of air and dries the paper quickly. When dry, the copies are removed by breaking the roll of paper just above the reel and releasing the small thumb-nut which engages the driving pulley attached to the shaft of the hard-rubber roller. This permits the reel to be reversed, and the copies drawn off are passed between the cutter-blades at the back of the machine, where they are separated, ready to be filled with the original letter. The cutter-blades are kept in contact by means of a spring pin adjustment, and being bevel ground are self-sharpening.

The hard-rubber, or main, roller is driven by a 3-to-1 internal gear, meshing into a pinion keyed to the crank shaft. This reducing gear allows the machine to be operated with the least possible effort, and permits the use of a shorter crank. It also reduces the copying speed, making it impossible to run copies through too quickly. The copier can also be driven successfully by a small motor.

All parts are interchangeable and easy of access. Bright parts are nickeled on copper. The rubber rollers are specially constructed, and run in phosphor-bronze bearings. The dampening roller is of brass nickel-plated, bulged at the center, tapering toward the ends. This removes all wrinkles and puts the greatest strain on the center of the paper.

The "Rapid Roller-Copier" avoids the use of wet cloths, blotters and oil boards. There are no annoying delays, as it is always ready for use. The pressure being uniform, the resulting copies are always as clear as the original. The original shows no signs of having been copied, and is always clear and presentable.

The machine has just been investigated by the Committee on Science and the Arts, and has received the award of the Edward Longstreth Medal of Merit. The machine is manufactured and sold by The Yawman & Erbe Manufacturing Company, Rochester and Philadelphia.

IT MAY INTEREST STEAM USERS to read the following description of an improved damper-regulator, manufactured by Wm. P. Dennis, 633 Arch Street, Philadelphia, for which specially meritorious features are claimed:

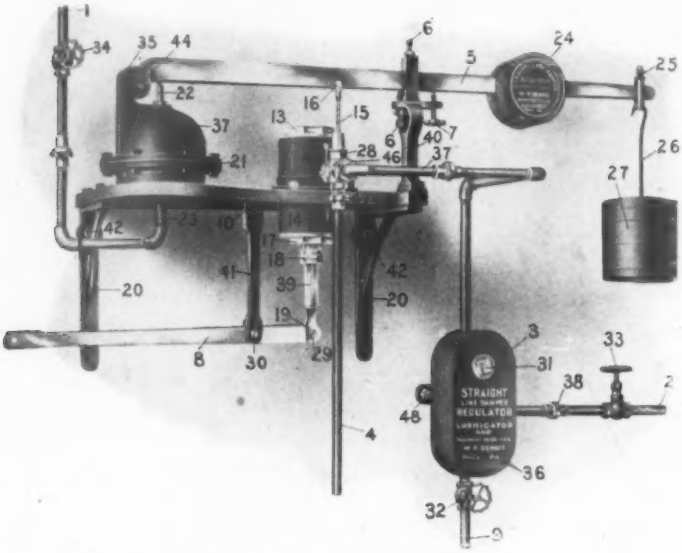
Referring to accompanying cut: (1) is a $\frac{3}{8}$-inch pipe leading from dome chamber which admits the pressure under the diaphragm. The connection to the boiler is made from any point where it is possible to get the direct steam pressure. On the top of the diaphragm is a pressure-cup and pin. The main lever rests with a knife-edge on the pressure-pin. The slightest changes of steam pressure cause the lever to rise or fall; the lever being counter-weighted to the desired pressure to be carried on the boilers.

The valve stem (15) is connected to the lever with a yoke and loose connection held in place by a $\frac{3}{16}$th hexagon nut. Any movement of the

lever causes the valve in the valve body to open or close the ports leading into the cylinder, giving the pressure either on top or bottom of the piston, which causes the piston-rod to travel up or down. This travel will throw the lever (8) in an upward or downward movement. At the extreme end of the damper lever (8) is attached the connection to the damper in the flues or stack.

The regulator is so accurately balanced that it will operate on $\frac{1}{20}$th of a pound change in steam pressure.

The sediment receiver and lubricator (3) is claimed to be a valuable attachment. If it is necessary to lubricate the regulator this can be done by removing the brass plug (31); (32) is the blow-off valve to remove any sediment coming into the sediment receiver from intake pipe (2).




The lock wheel (7) also is claimed to be a valuable acquisition to the regulator. By its means the damper can be entirely shut off and securely locked, thus preventing any possible chance of the damper becoming open, drawing up the fire and raising the steam during the night; also, the lever can be so adjusted as to have the damper open at any desired point (say one-quarter) to carry off the gases. If steam should possibly come up during the night, as soon as the pressure for which the damper is set is reached it would close the damper tight. The regulator will operate from any point of the stroke, ¼, ½ or ¾, or any fraction of the stroke. The apparatus is not a wide open and shut regulator.

Further information may be obtained by addressing the manufacturer, William P. Dennis, 633 Arch Street, Philadelphia, Pa.

## Improved Machinery, Apparatus and Processes.

[This department will contain from month to month descriptions of new machines, apparatus and processes. The data, for which the editor must depend largely on information derived from interested sources, will be carefully edited. The Committee disclaims responsibility.—THE COMMITTEE ON PUBLICATIONS.]

### THE RENOLD SILENT CHAIN.

To properly appreciate the advantages possessed by the Renold Silent Chain, which are set forth in what follows, it will be necessary to allude to some of the defects of ordinary chains, and then to point out how these are overcome by the Renold type. The defects of ordinary chains are:

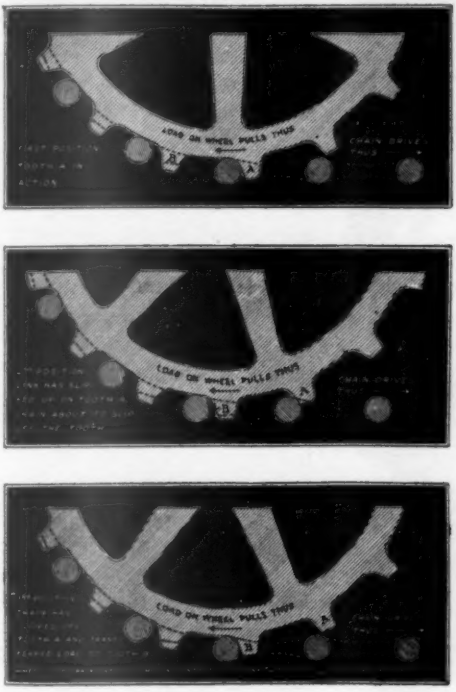


FIG. 1.

First, the stretching of the pitch, caused by wear, which occurs to such an extent that the chain becomes useless before the links are worn out.

Second, one tooth only sustains the load, and, passing it on from tooth to tooth, a more or less uneven, noisy and hard-working action is produced. This transfer of load is very clearly illustrated in the accompanying *Fig. 1*.

The Renold Silent Chain was designed with a view, first, of lessening the stretching by increasing the wearing surface of pin and bearing; second, of reducing the noise, by so designing the tooth that the load shall glide gradually from tooth to tooth; third, of reducing the work of the tooth by making the tooth spaces not only just sufficiently large for the chain to bed, but also for the loaded chains to glide, however slightly, on the wheel circumference as one tooth after another goes out of gear. The work becomes thus divided between the tooth and frictional surface contact of the wheel circumference. This gliding action is shown in lower half of *Fig. 2*. It will be noticed that

every tooth in mesh is in direct working contact with the chains. This results in a minimum of wear and a maximum of efficiency.

*Fig. 3* illustrates the latest development of the Renold Silent Chain, namely, the bushed type, which was designed and patented by James Mapes Dodge, of Philadelphia. In this chain the wear is transferred from the hole in link to case-hardened bushings, thereby reducing elongation to a minimum; the bushing presents an unbroken surface to the pin, greatly increasing the bearing area, and in addition acts as a retaining wall for lubrication, as a direct result of which the chain can be run at a higher speed than the non-bushed type, which allowed the lubricant to escape and the pins to become dry and eventually burn. In the bushed type there is absolutely no connection between pin and hole of link, consequently the pin is at all times free to rotate and the wear is equally distributed.

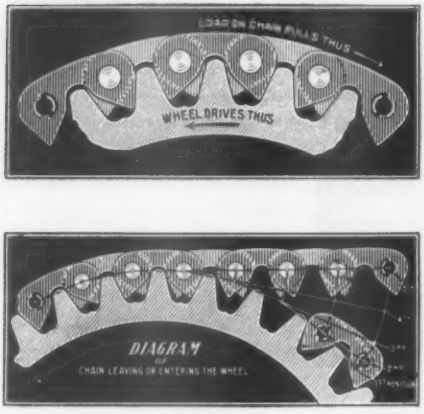



FIG. 2.—The action of the Silent Chain.

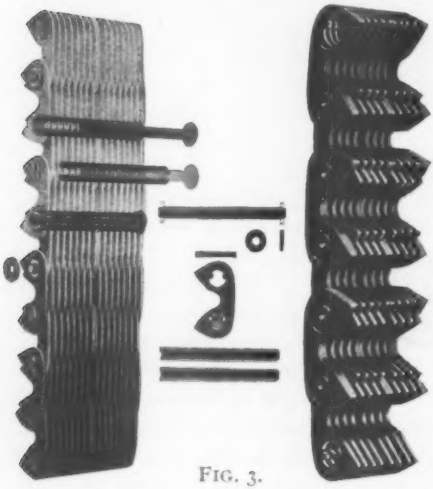


FIG. 3.

Plain Side Links
1/4", 5/16", 3/4"
Pitches

Countersunk Side Links
1", 1 1/4", 1 1/2", 1 3/4", 2"
Pitches

*Fig. 4* illustrates a 500 horse-power drive from a motor to a gas blower. It will be noticed that there are two strands of chain in operation. As it is practically impossible to make pins and bushings accurate enough to assemble properly in chains over 12 inches wide, the 20-inch width necessary is obtained by using two chains each 10 inches wide.

To distribute the load properly between the two chains and to prevent unequal wear, two wheels with removable hubs, the latter having external lugs which correspond to lugs on the inside of the rim of wheel, are employed, and between

each pair of lugs is inserted a spring of sufficient strength to sustain the pull to be transmitted.

This method of transmitting power is said to be rapidly growing in favor, eliminating, as it does, fixed centers, economizing space, and reducing power loss. The efficiency of this drive by test is claimed to be as high as 98·2 per cent. The Link-Belt Engineering Company, Nicetown, Philadelphia, are the manufacturers.

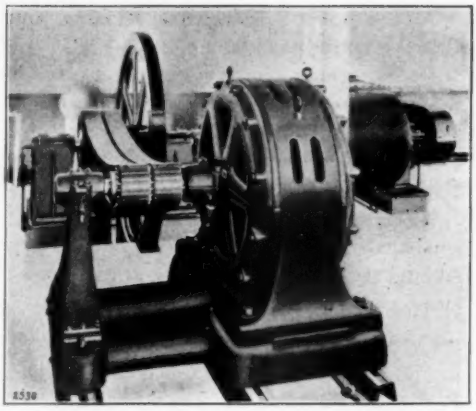


FIG. 4.—500 H. P. Silent Chain Drive operating Gas Blower. Speed, 1,900 feet per minute.

## NILES FORTY-TON YARD CRANE.

Illustration is given herewith of the latest type of an approved and economical apparatus for the handling of heavy and bulky freight in a railroad yard. The view shows a portion of the yard of the Buffalo & Allegheny Valley Division of the Pennsylvania Railroad Company, and includes a 40-ton Niles Overhead Electric Traveling Crane, 48 feet span, and a substantial structural steel runway 40 feet long. The crane spans three tracks, and leaves a wide passageway which gives ample approach for teams and trucks on one side of the cars covered by this apparatus.

In addition to the main hook, a quick-running auxiliary hook of 5 tons capacity is provided for the rapid and efficient handling of light loads, which performs by far the greater part of the service of the crane.

The bridge consists of two heavy curved girders, of box section. It is driven longitudinally on the runway by an electric motor located on the front girder, which is geared to the truck wheels on either side, the motion being controlled by a foot brake located in the operator s cage, which acts directly upon the armature shaft of the motor.

A foot bridge is provided the entire length of the span, with customary guard rail.

The bridge trucks are of built-up type, securely fastened with the utmost rigidity to the girders, provided with heavy cast steel, double-flanged truck wheels, with treads accurately finished to uniform diameter.

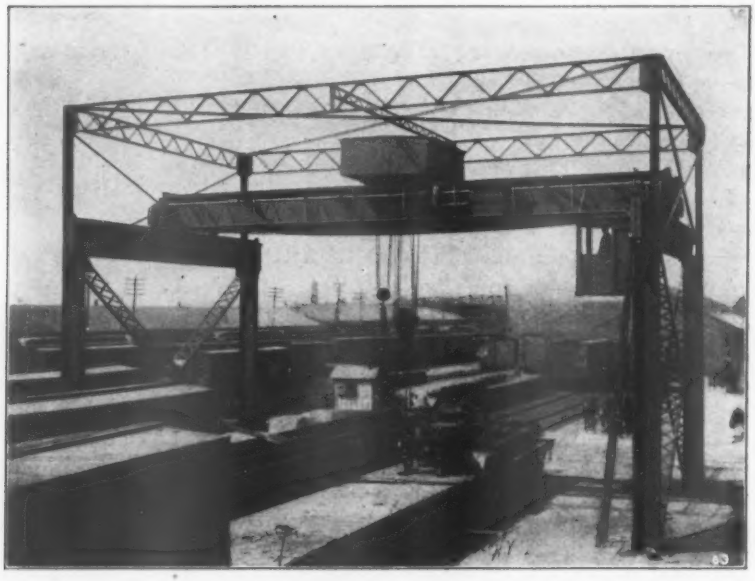
The trolley is the standard type used on overhead cranes, consisting of heavy side frames securely bolted together and kept in perfect alignment by a separator.

All the gearing is cut from the solid and runs encased in oil, which gives the entire mechanism an unusually high mechanical efficiency.

Both hoists are provided with mechanical and electric brakes, also circuit breaker and limit switches to prevent overwinding and consequent damage to the crane or its load.

The trolley, operator's cage and bridge drive motor are of the inclosed type, affording suitable protection from the weather.

The runway, it will be noticed, is of substantial construction. It consists of four built-up columns carrying runways of riveted plate and channel construction, laterally braced by overhead struts and chords of lattice construction.



It will be readily appreciated that an equipment of this character has a much greater capacity than the average pillar or swinging crane, which, where any is in use, is usually installed at railroad freight stations.

If at any time it is desired to cover increased acreage by the hook, the length of runways is readily increased by adding additional spans.

This crane is notable also because of the extra height of lift, which enables the loaded hook to clear the top of box cars or other obstructions while performing the functions of its regular service of loading and unloading.

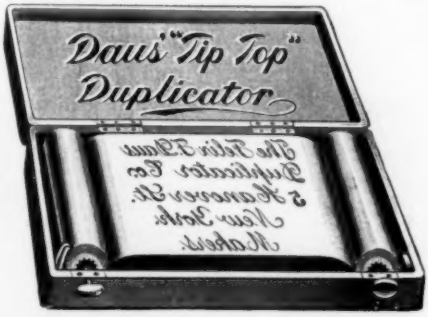
The complete apparatus was manufactured, installed and erected by the crane department of the Niles-Bement-Pond Company, Meadow and Mifflin Streets, Philadelphia, Pa.

## Improved Machinery, Apparatus and Processes.

[This department will contain from month to month descriptions of new machines, apparatus and processes. The data, for which the editor must depend largely on information derived from interested sources, will be carefully edited. The Committee disclaims responsibility.—THE COMMITTEE ON PUBLICATIONS.]

### AN IMPROVED DUPLICATOR.

The apparatus and method described herewith are claimed to afford an exceptionally convenient and cleanly process for duplicating letters and typewritten matter, reproducing these in black ink so faithfully that the copy can hardly be distinguished from the original.




The apparatus, which is shown in the accompanying cut, contains 5½ yards of rolled printing surface, which can be used repeatedly for making duplicates.

The manipulation of the device is quite simple. The coated paper is wound upon two cylindrical rolls, and is brought to suitable tension for use by operating the hand-gear shown in the picture. The original is written, with a special ink supplied by the manufacturers, on a hard, smooth, ledger paper. For typewriting, they furnish a purple duplicator ribbon, which is said to be excellently adapted both for duplicating and correspondence. The reproductions, it is said, can be made on any kind of paper; the smoother this is, however, the better the result.

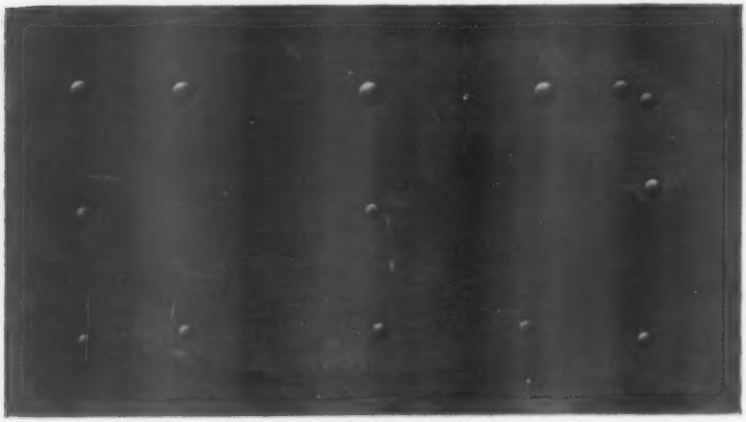
The operation is as follows: The original, when dry, is laid face down on the printing surface, gently smoothed down by hand, and left to adhere for about two minutes. This produces the negative. On the negative thus produced, the sheets to be printed are immediately and successively placed, and the impression is taken by passing gently over the sheet with a rubber roller. As rapidly as the impression is made, the sheet is removed and a clean sheet substituted until the desired number of copies (100 to 150) is made.

After the desired lot of copies is made, the printing surface is rolled to right or left, so that a fresh printing surface will be presented. No washing is required. The old ink of previous negatives will be entirely absorbed in a few days, and, although visible, will not interfere with making a clean copy from another original. Thus, the same roll of 5½

yards of printing surface, the manufacturers state, can be used from five to ten times over and over again, before becoming so saturated as to interfere with the production of clean copies. All needful supplies are furnished with the apparatus; and can be renewed as may be necessary. The Felix F. Daus Duplicator Company, 111 John Street, New York, are the manufacturers.

## IMPROVED INDENTATION TESTING MACHINE.

For various purposes it is absolutely necessary to have an exactly uniform material as regards some of its physical properties, and thus the Bureau of Engraving at Washington, D. C., noted a lack of uniform



hardness in steel plates which is so essential in the use of their engravers' plates.

On these plates under discussion the original impression is made; then from them it is transferred to the steel rollers from which the final engraving plates are made. It can thus be seen how important it is that the plate be of uniform hardness, both to the engraver and the prolonging of the life of the plate, and the uniform character of the engravings.

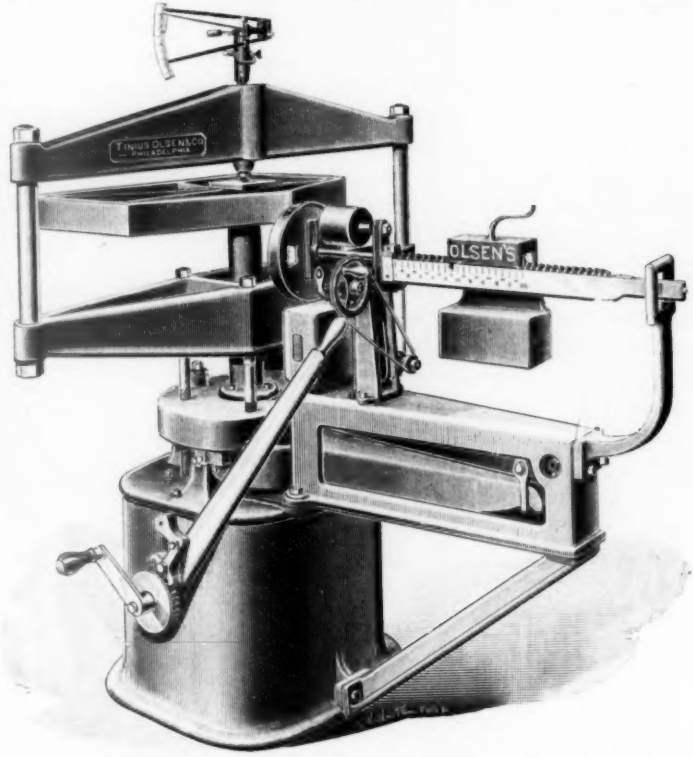
This state of affairs was presented to Tinius Olsen & Co., Philadelphia, Pa., and the task was left to them to devise a means of testing the plates for their uniformity. Various tools were tried to secure the best means of obtaining a positive and unvarying form of indentation.

Owing to the temper and quality of the plates, all tools failed with the exception of a "Standard Steel Ball." This accomplished the

indentation satisfactorily, and in case of wear or break could readily be replaced.

A portion of an engraver's plate was then tested by this means, and with the identical pressure a marked difference in the depth of the indentation was observed and is here illustrated by cut of plate so tested.

This great variation was much more than had been anticipated, and so an indentation machine was designed by Tinius Olsen & Co. and




adopted by the Bureau of Engraving. This machine is shown by the accompanying cut and will be understood from the following description.

The machine was designed and constructed so as to cover in the best possible manner the three points in question: First, application of pressure to material tested; second, weighing of pressure applied; third, depth of indentation in the material.

The pressure is applied by a hand-lever and ratchet, seen in illustration, which operates the four-screw mechanism so well known in this type of machine.

The load applied to the specimen is transmitted by a series of levers to, and weighed on, the dial vernier beam as shown.

The plate to be tested is placed between the intermediate platen shown and the compression head situated at the top of the machine, and is capable of operating on a full-size engraver's plate. On this upper head is secured the instrument for measuring the depth of indentation. This instrument is connected firmly to the machine and measures the indentation to the 1-10,000 part of an inch, recording the same automatically as the pressure is applied to the specimen.

A 3-8 inch steel ball was found most suited and was adopted as the standard tool for all indentation tests. The ball is fitted to the instrument and can easily be removed and replaced in case of wear or breakage.

To test plates in this machine two methods may be used, by keeping either the pressure or the depth of indentation a constant factor. The first method is the preferable one and has been used thus far in all tests.

A set of very interesting curves can then be plotted showing the extent of the soft spots, and from their position in the plates their cause might be determined and obviated.

A machine of this kind is now being built for the laboratory of Tinius Olsen & Co., so that commercial tests of this character can in the future be made in connection with other tests of material. A series of tests is also to be made on material for determining the results of different methods of tempering as well as results for the hardness of different metals. The latter appears to be quite an important item and important results are expected. An endeavor will be made to compare these results with those obtained on the same material in other tests, to determine whether there is a relation between the results of the hardness test and other tests now in use.

# Improved Machinery, Apparatus and Processes.

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## REED'S SPEED JACK.

Following the discussion of the subject of "Electric Motor Drives for Machine Tools," published elsewhere in this impression, Mr. C. J. Reed described and exhibited in operation a speed controller of his

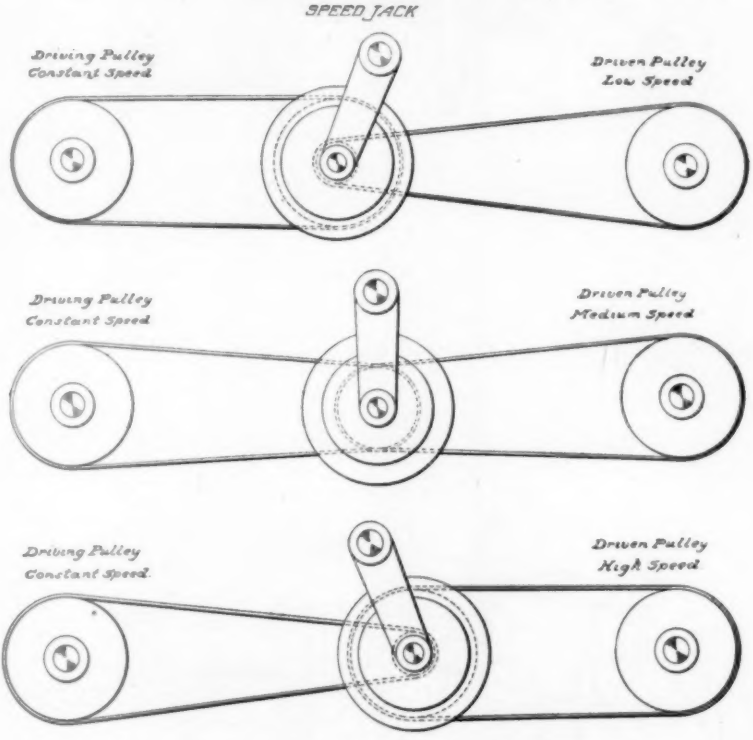


FIG. 1.

invention. The construction and action of the apparatus will be understood from the following description:

This mechanism consists of two expansible drums or pulleys operating in conjunction, the one adapted to expand, while the other simultaneously contracts in such a manner as to keep a practically uniform tension on the belt or chain.

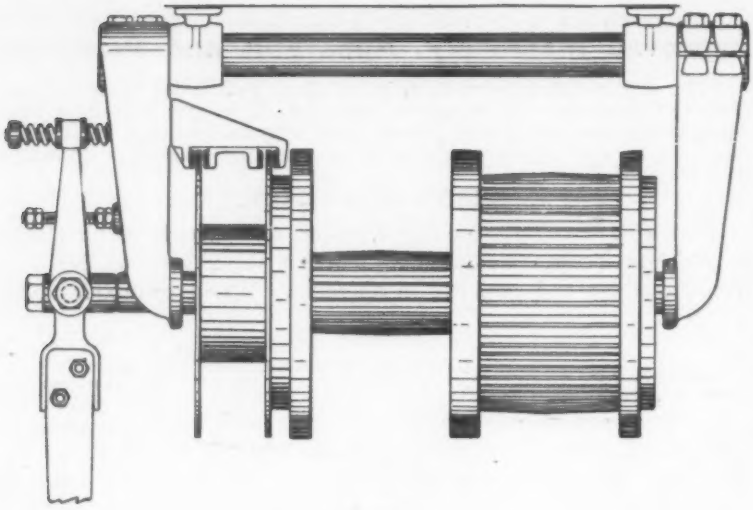

FIG. 2.

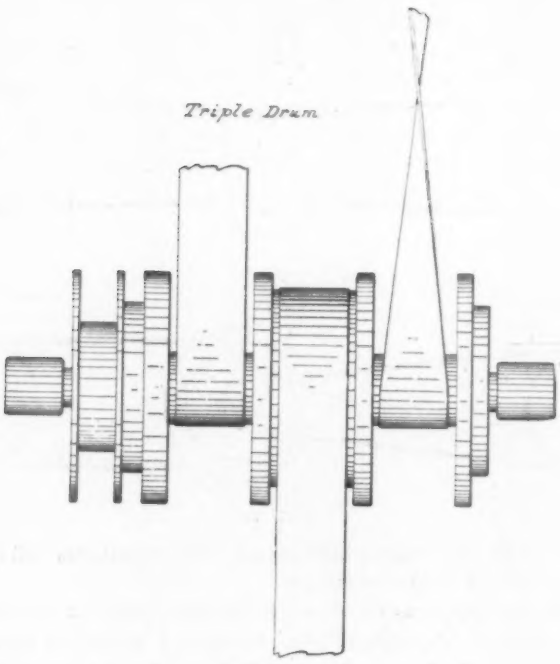


FIG. 4

The apparatus is built of two different forms or types. In one type the two drums carrying a single belt are on different shafts—one on the driving and the other on the driven shaft. In the second type, called

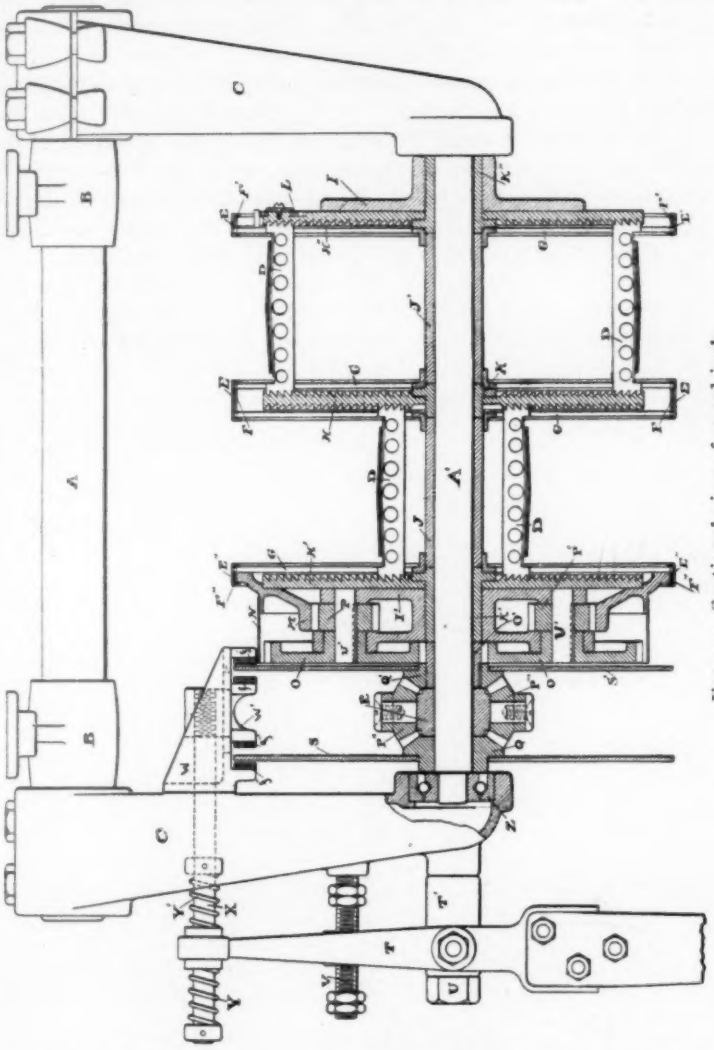

FIG. 3.—Sectional view of speed jack.

the "speed jack," both expansible drums (in some cases more than two drums) are on the same shaft, which is mounted so as to reciprocate between the driving and driven shafts, automatically taking a position which keeps the belt tension uniform. In this form each of the expansi-

ble drums is separately belted to a non-expansible pulley—one on the driving and one on the driven shaft.

*Fig. 1* shows the speed jack in three positions—those of minimum, medium and maximum speed. *Fig. 2* shows a connected view, and *Fig. 3* a longitudinal section of the jack. Each drum consists of a circle of parallel slats or rim-sections, whose toothed ends are held in the grooves of two scroll-threaded discs, mounted and keyed to the shaft. The rim-sections are equally spaced in all positions by means of radially slotted guide plates movably mounted on the shaft. Rotation of the guide plates, with reference to the scrolls, causes the rim-sections to move towards or from the center. Suitable mechanical means are provided for producing this relative movement of the scrolls and guide plates, either by hand-power or power supplied by the apparatus.

*Fig. 4* shows a jack with three drums, two of which operate together and in opposition to the middle drum. This gives one open and one crossed belt on the driven shaft for direct and reversed motion.

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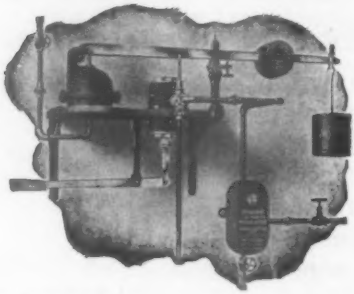

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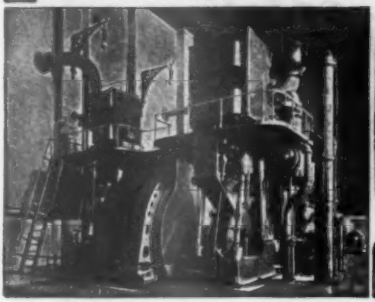

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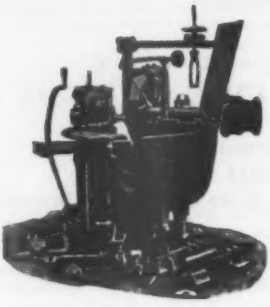

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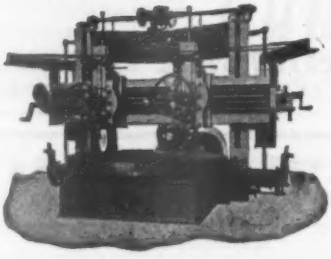

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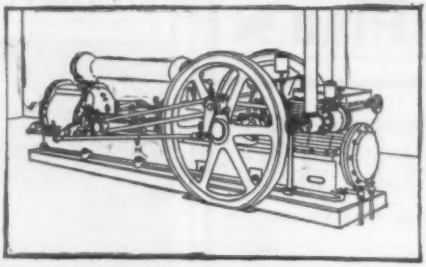

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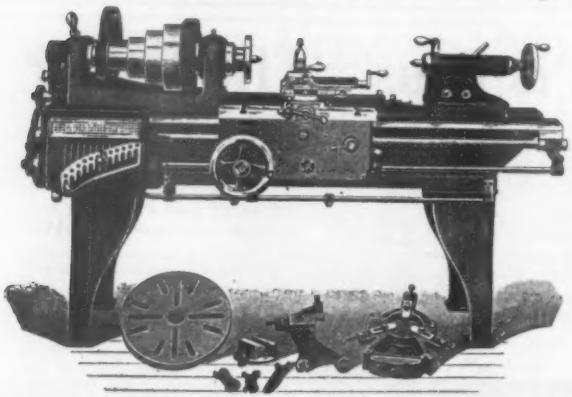

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2. Each competitor must transmit to the Secretary of the FRANKLIN INSTITUTE a memoir, describing in detail the apparatus, the mode of experimenting, and the results: and all memoirs received by him before the first day of January, one thousand nine hundred and five will, as soon as possible after this date, be transmitted to the Committee of Judges.

3. The Board of Managers of the FRANKLIN INSTITUTE shall, before the first day of January, one thousand nine hundred and five, select three citizens of the United States of competent scientific ability, to whom the memoir shall be referred; and the said Judges shall examine the memoirs and report to the FRANKLIN INSTITUTE whether, in their opinion any, and, if so, which of the memoirs is worthy of the Premium. And, on their report, the FRANKLIN INSTITUTE shall decide whether the Premium shall be awarded as recommended by the Judges.

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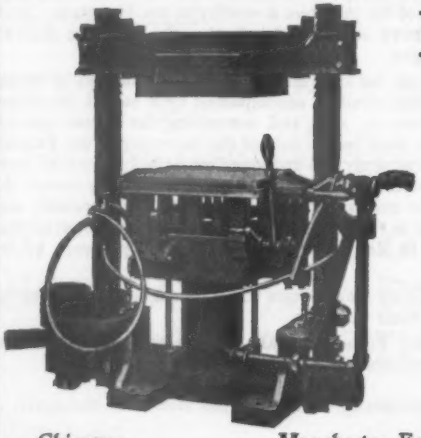

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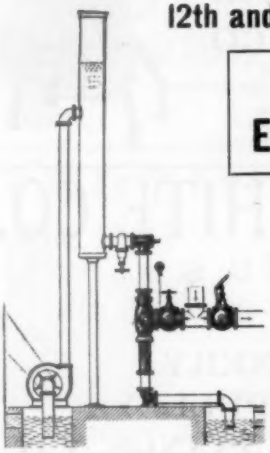

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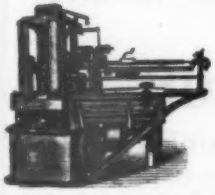

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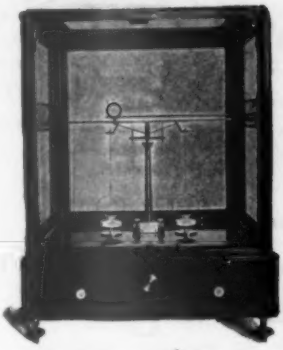

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